PROCESSING FUNCTIONS OF VERY LOW BIRTHWEIGHT CHILDREN AT EIGHT YEARS OF AGE

By

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Advances in medical technology have resulted in growing numbers of very low birthweight (<1501 grams) babies surviving and reaching school age. There is increasing concern that these children may be at risk for later learning problems. Although researchers have found a higher rate of learning disabilities in very low birthweight (VLBW) children than in their full-term peers, few researchers have examined the cognitive processing functions of VLBW children.

According to synactive developmental theory, babies born prematurely are placed in environments to which they are poorly matched. The result of this discrepant organism-environmental fit is that premature babies often develop

faulty adaptation patterns that may cause physiological changes within the developing brain. These changes can lead to later information processing difficulties. Few researchers have followed this population longitudinally to determine whether processing problems exist in VLBW children.

The purpose of this study was to examine cognitive processing functions of 8-year-old children born with very low birthweights. The processing functions examined were those proposed by Luria and later described by Naglieri and Das; specifically, organization, simultaneous processing, successive processing, and attention. These processes were examined using the Cognitive Assessment System. The Cognitive Assessment System was individually administered to 51 children, 21 VLBW children and 30 full-term children. Very low birthweight and full-term children were similar demographically on variables of age, race, gender, and socioeconomic status.

The four area scores of the Cognitive Assessment System were compared between VLBW and full-term children using a multiple analysis of covariance. Covariates included mother's age and educational level at the time of birth and child's age at the time of testing. Results of the analysis revealed significantly lower scores for the VLBW children in

the areas of attention, simultaneous processing, and successive processing. The most significant difference emerged in the area of attention. No difference was found between the two groups in the area of organization. Results of this study enabled to investigator to support synactive developmental theory and conclude that VLBW children are at risk for later cognitive processing difficulties.

CHAPTER 1

INTRODUCTION

The developmental outcome of very low birthweight (VLBW) babies has been a topic of interest to educational and medical researchers over the past two decades. The advent of intensive care nurseries and advances in medical technology have resulted in growing numbers of VLBW survivors and intensified interest in their developmental outcomes. There has been increasing concern that these babies may be at risk for later developmental difficulties.

Recent studies have allowed for the conclusion that very low birthweight and full-term babies have similar IQs throughout early and later childhood (Als, Duffy, & McAnulty, 1988; Bennett, Robinson, & Sells, 1982; Field, Dempsey, & Shuman, 1982; Greenberg & Crnic, 1988; Kitchen et al., 1980; Marlow, D'Souza, & Chiswick, 1987; Nickel, Bennett, & Lamson, 1982). However, subtle differences between these two groups have been found to exist that may be indicative of neurological dysfunction (Als et al., 1988; Hertzig, 1981; Hunt, Cooper, & Tooley, 1988; Sigman, 1982).

Children born with low birthweights have demonstrated a higher incidence of attentional deficits (Als et al., 1988; Blennow, Pleven, Lindroth, & Johansson, 1986; Hunt et al., 1988; Hunt, Tooley, & Harvin, 1982), visual-motor integration problems (Blennow et al., 1986; Francis-Williams & Davies, 1974; Hunt et al., 1982, 1988; Siegel, 1983), and motor deficits (Blennow et al., 1986; Greenberg & Crnic, 1988; Mazer, Piper, & Ramsay, 1988) than full-term counterparts. Very Low Birthweight newborns have been determined to have a higher risk for organizational difficulties in infancy (Als et al., 1988). Neurological "soft-signs" have been identified more often in VLBW children than in their full-term peers (Driscoll et al., 1982; Francis-Williams & Davies, 1974; Hertzig, 1981; McCormick, 1985) as have reading problems (Francis-Williams & Davies, 1974; Nickel et al., 1982).

Theoretical Framework

Possible differences between children born of very low birthweights and those born at term can be interpreted within the framework of synactive developmental theory (Als, 1978, 1982, 1985, 1986; Als et al., 1988; Linton, 1986). According to this theory, environmental factors influence brain development through an interplay of sensory information and experience. Between 26 and 40 weeks' gestation, areas of the brain, especially the association

areas, are rapidly maturing and differentiating. Results of animal studies have led researchers to conclude that there are sensitive periods of brain development during which specific environmental input is necessary for development to proceed normally (Hubel, Wiesel, & LeVay, 1977). Preterm birth may have a major impact on the developing brain because the experiences of premature babies are not those that are biologically expected (i.e., those that would normally occur).

The result of preterm birth is a discrepant organism-environment fit. Premature babies are placed in environments to which they are poorly matched and often have problems adapting to these new environments. Consequently, such babies are at risk for developing faulty adaptation patterns. In an attempt to protect themselves from offensive environmental input, preterm babies may develop defense behaviors such as gaze aversion, closing eyes, or flaccidity. Preterm babies may not be able to attend or respond to environmental input without causing stress to autonomic, motor, and physiological systems. The experiences of such babies are often distorted; therefore, such babies may develop defense behaviors and disorganized approaches for dealing with environmental input. According to synactive theory, the resulting distortions and disorganizations can cause changes in the developing brain

and place the premature baby at risk for later processing and organizational difficulties.

Statement of the Problem

Improved neonatal care and decreasing mortality among VLBW populations have resulted in increasing numbers of these children reaching school age (Levene & Dubowitz, 1982; Saigal, Rosenbaum, Stoskopf, & Sinclair, 1984). Although the decrease in mortality has not been accompanied by an increased incidence of severely handicapping conditions among VLBW children (Chamberlin, 1987; Drillien, Thomson, & Burgoyne, 1980), such children continue to be at risk for learning difficulties despite IQs that are typically in the average range (Hunt et al., 1982; 1988). The increased risk status of VLBW children for later learning difficulties has been shown to exist even when socioeconomic status is accounted for, further suggesting the presence of subtle neurological differences in VLBW children (Hertzig, 1981; Lasky et al., 1987; O'Reilly, O'Reilly, & Furono, 1986; Sigman, 1982).

The extent of differences between VLBW children and children born at term has not been observed until school age (Hirata et al., 1983; Hunt et al., 1982; Hunt et al., 1988; Pederson, Evans, Chance, Bento, & Fox, 1988) and few studies have been devoted to the longitudinal study of VLBW children. Although some researchers have found VLBW

children to be at higher risk for learning disabilities (Nickel et al., 1982; Hunt et al., 1988), knowledge of cognitive processing styles, organizational abilities, and attentional processes in these children is lacking. Only very recently have researchers identified attentional and organizational difficulties in preterm neonates that continue to exist during infancy (Als et al., 1988). The degree to which these difficulties continue to exist into later childhood is unknown.

There is a need to determine why VLBW children are at risk for later learning difficulties. Perhaps these children have subtle processing deficiencies similar to those that have been observed during the neonatal period; specifically, difficulty organizing and processing environmental input. Knowledge of information processing, organizational, and attentional processes of VLBW children may facilitate educational programming for these children and perhaps ultimately reduce their high rate of educational difficulties. Additionally, examination of these processes in VLBW children at school age is necessary to support the synactive theory of development in terms of long range, neurologically-based effects of premature birth.

Purpose of the Study

The purpose of this study was to investigate information processing, organizational, and attentional

processes in 8-year-old children who were born with very low birthweights. Global intellectual scores have generally failed to differentiate between VLBW and full-term children. Sole use of such scores has been criticized because of their tendency to obscure subtle or discrete abilities (Lezak, 1988; Naglieri & Das, 1988). In this study, the subtle processes that may contribute to learning difficulties in VLBW children were investigated.

Assessment Model

Luria (1980) described three functions of the brain: arousal, coding, and planning/organization. Problems with organization and arousal have been found to exist at higher rates in VLBW neonates than in those born at term (Als, 1985; 1986; Als et al., 1988; Ruff, 1986). Additionally, organizational difficulties have been found to exist at higher rates in VLBW children during infancy (Als et al., 1988). Information about coding processes in VLBW children is currently lacking, but synactive theory would suggest that these children have deficient coding processes relative to full-term peers.

Most traditional intelligence tests do not adequately measure planning and arousal, and few can successfully measure coding processes (Naglieri & Das, 1988). The PASS (Planning-Arousal-Successive-Simultaneous) model of assessment proposed by Das (1972) and recently described by

Naglieri and Das (1988) is an effective measurement system for examining these processes. The Cognitive Assessment System (CAS), based on the PASS model and developed by Naglieri and Das (1987), was used in this study to examine organizational, attentional, and coding processes in 8-year-old children who were born of VLBW. Eight-year-old children were chosen because of the need for longitudinal follow-up and the tendency for subtle learning problems to first manifest themselves during this time (Pederson et al., 1988).

Research Questions

The following research questions are examined in this study in relation to children at 8 years of age:

1) Do VLBW children have lower successive processing scores than full-term peers?
2) Do VLBW children have lower simultaneous processing scores than full-term peers?
3) Do VLBW children have lower organizational processing scores than full-term peers?
4) Do VLBW children have lower attentional processing scores than full-term peers?

Delimitations of the Study

This study is delimited geographically to the northwest Florida area referred to as "the Panhandle"and nearby states. Subjects were obtained from northwest areas of

Florida ranging geographically from Pensacola, a medium-sized city located in Escambia county, to Tallahassee, a medium-sized city located in Leon County. Additionally, subjects were obtained from various small towns and rural areas of southern Alabama and southern Mississippi. Subjects for the study were attending public schools and most subjects were 8 years of age. Two subjects, one full-term and one VLBW, were 9 years, 2 months of age. No procedures for randomizing or matching were applied. However, attempts were made to obtain similar samples of VLBW and full-term children on the demographic variables of age, gender, race, and socioeconomic status. Socioeconomic status was defined by the mother's need for federal assistance in paying hospital bills at the time of the child's birth (i.e. medicaid). The independent variables examined in this study were those measured by the Cognitive Assessment System; specifically, organization, simultaneous processing, successive processing, and attention.

Limitations of the Study

Since this study included only 8- and 9-year-old children, the findings should not be generalized to children of other ages. Additionally, because this study contained fewer VLBW children of lower socioeconomic status than has been reported nationally, caution should be used when generalizing results of this study to the entire population

of VLBW children. Caution should also be used when generalizing results of this study to VLBW children outside of the Florida panhandle area, particularly to those VLBW children residing in large metropolitan areas.

Another limitation of this study involved the instrumentation. The Cognitive Assessment System was not normed and there was a lack of reliability and validity information on the instrument at the time of the study. The CAS was chosen over other existing instruments because it provided a better measure of the variables of interest. However, the lack of normative data and questions about the reliability and validity of the CAS were limitations in this study.

Relatedly, the fact that one examiner tested all of the subjects was a limitation. The possibility of experimenter bias existed, but was minimized by the fact that the CAS is an objective instrument. Additionally, subjects were scheduled several weeks in advance so as to maintain some degree of anonymity regarding group membership.

Definition of Terms

A number of terms are used that require further definition.

Arousal. Arousal is a unit identified in Luria's (1973) model, it is the prerequisite for all mental activity. Arousal allows an individual to direct attention

toward relevant stimuli, direct attention away from irrelevant stimuli, and divide attention between activities without decreased efficiency.

Coding. Coding is a unit identified in Luria's (1973) model, coding is involved in receiving, processing, and storing information. Luria (1966) identified two coding processes--successive and simultaneous.

Cognitive Assessment System. The Cognitive Assessment System is an instrument developed by Naglieri and Das (1987) to examine four areas of cognitive functioning: attention, successive processing, simultaneous processing, and organization.

Full-Term. Full-term children refer to those children born with birthweights of at least 2500 grams.

PASS Model of Assessment. The PASS model of assessment is an information-integration model first proposed by Das (1972) that explains cognitive functioning in terms of three brain units--arousal, coding, and planning.

Planning. Planning is a unit identified in Luria's model (1973) that is involved in formulating plans of action, regulating behavior so that it corresponds to plans, comparing results of actions to intentions, and correcting errors.

Simultaneous Processing. Simultaneous processing is one of the coding processes described by Luria (1973) in which each element of a stimulus is related to all other elements. Simultaneous activities are said to be surveyable because all aspects of the stimulus are accessible during inspection.

Successive Processing. Successive processing is one of the coding processes described by Luria (1973) in which each element of a stimulus is related only to adjacent elements. Therefore, stimuli are integrated into series and synthesized into a chain-like progression of elements.

Synactive Developmental Theory. Synactive developmental theory is the theory proposed by Als (1978) to explain the difficulties that preterm babies often experience when exposed to environmental stimulation. The organism-environmental mismatch that exists with these babies may lead to long range problems with information processing according to synactive theory.

Very Low Birthweight. Very low birthweight children refer to those children born with birthweights less than 1501 grams.

Summary

There is a need to examine long-term cognitive processing functions of VLBW children. Although VLBW children have been found to have cognitive processing

deficits as infants and young children, studies that examine processing functions of older VLBW children are lacking. It was the intent of this study to provide information about cognitive processing functions of VLBW children at 8 years of age. Specifically, organization, simultaneous processing, successive processing, and attention were examined. The results of this study have implications for educators and others who work with VLBW babies and children.

A review of related literature is presented in Chapter II. Chapter III presents a description of methodology. Results are then presented, discussed, and related to previous research findings in Chapter IV. Summary of findings, conclusions, and recommendations for future research are presented in Chapter V.

CHAPTER II

REVIEW OF LITERATURE

In Chapter II, an analysis of the professional literature involving outcomes of VLBW children, synactive developmental theory, educational needs of VLBW children, and the Cognitive Assessment System are presented. The chapter is divided into eight major sections. Selection criteria for the literature that was reviewed and an overview of the importance of longitudinal follow-up of VLBW children are presented. Included in the overview is a discussion of mortality and morbidity of VLBW children. In the subsequent sections, literature related to developmental outcomes, physiological development, and educational needs of VLBW children, synactive developmental theory, and the Cognitive Assessment System is reviewed. The chapter concludes with a summary and implications of previous research as it relates to the present study.

Selection of Relevant Literature

An initial step in the review of the literature was that of determining the criteria for the inclusion of references. All relevant studies completed in the last 10 years (1980-1990) were examined. In addition, any notable

research cited in the literature earlier than the 1980 year time period was also considered.

Professional literature concerning outcomes of VLBW children and the Cognitive Assessment System was required to meet the following criteria to be included in the review:

1. The subjects and the settings in which the experimentation took place had to be thoroughly described.
2. The treatment conditions and experimental procedures were detailed enough to permit replication.
3. The experimental design and data analysis procedures were presented without significant losses of information.
4. The interpretations of the experimenter had to be consistent with the results displayed.

In order to exhaustively review the literature related to outcomes of VLBW children, synactive developmental theory, and the Cognitive Assessment System, the following sources were used for the literature review: Dissertation Abstracts International, Educational Resources Information Clearinghouse (ERIC), Psychological Abstracts, and Current Index to Journals in Education (CIJE). References initially selected were located through the libraries at the University of Florida, the University of West Florida, and

Sacred Heart Hospital, through the interlibrary loan system, or through other professionals in the field. Descriptors used in this literature search included VLBW, processing, premature, coding, attention, and organization.

The references that were selected were critically reviewed and those that described empirical investigations were chosen based on the investigator's judgment that the references presented a clear description of subject selection, methodology, and results. Professional literature other than empirical investigations were also included if, in the author's judgment, the information that was included provided a valuable contribution to the knowledge base about or an understanding of VLBW children, synactive developmental theory, or the Cognitive Assessment System.

Overview

Very low birthweight (VLBW) infants account for approximately 1.5% of all births (Peterson, 1988; Slater, Naqvi, Andrew, & Haynes, 1987), but constitute the largest group of newborns at risk for later handicaps (Levene & Dubowitz, 1982). A meta-analysis of nine studies revealed that there was a 58% survival rate for VLBW infants during the 1970s (Levene & Dubowitz, 1982). Survival rates of infants weighing less than 1000 grams at birth have doubled since the middle 1970s (Saigal et al., 1984). The large

number of VLBW survivors has led to increasing concern about the developmental outcomes for this population.

Although the decreasing mortality rate among VLBW children has not been accompanied by a proportionate increase in major handicapping conditions (Chamberlin, 1987; Drillien et al., 1980; Hunt et al., 1982; Kraybill, Kennedy, Teplin, & Campbell, 1984; Saigal et al., 1984; Stewart, Reynolds, & Lipscomb, 1981), these infants contribute disproportionately to the number of children with neurological and developmental delays (Hunt et al., 1988; Siegel, 1983; Slater et al., 1987). VLBW babies are 3 times as likely as full-term babies to develop later neurodevelopmental handicaps (McCormick, 1985).

The differences between VLBW and full-term children are subtle and difficult to identify. However, as many as one-third of VLBW children encounter academic or social adjustment problems at school age (Blennow et al., 1986). A follow-up study of 25 children who weighed less than 1000 grams at birth, revealed that 64% had been or were currently receiving special education services at 6 to 16 years of age (Nickel et al., 1982). Only 28% of VLBW children were rated by teachers as achieving on or above grade level. Hunt et al., (1988) found that 16.7% of VLBW children had learning disabilities at age 8. It appears from results of these studies that underlying differences exist between children

born with very low birthweights and those born at term. These differences may have been masked by global intellectual measures often used in research (Aylward, 1988; Pederson et al., 1988). However, subtle problems have been found to exist at higher rates in VLBW children than in children born at term.

Developmental Outcomes of VLBW Children

Studies examining intellectual functioning of VLBW children have generally found them to be within average ranges on global measures. Although some researchers have found statistically different intelligence quotients (IQs) in these two populations, differences have generally been small. Very low birthweight children as a group tend to have average IQs. A general problem with much of the research in the area of developmental outcomes of VLBW children concerns the definition of VLBW. Although VLBW has traditionally been defined as weighing less than 1501 grams at birth, many researchers have included children weighing more than 1501 grams in their samples while others have limited their samples to those weighing less than 1000 grams at birth. Birthweights of samples of VLBW children are specified in the following literature review when they deviate from the traditional definition of VLBW. Unless otherwise stated, VLBW children in the studies reviewed included only those weighing less than 1501 grams at birth.

Intellectual Functioning of VLBW Children

Kitchen and colleagues (1980), in a follow-up study of 158 VLBW survivors, found that VLBW children had IQs in the average range at age 8, although their scores were slightly lower than those of children in the full-term control group. Similarly, Field, Dempsey, and Shuman (1982) followed 56 preterm children weighing less than 1600 grams at birth. At age 5, preterm children scored slightly lower than full-term children on the McCarthy Scales. However, mean scores for the preterm children were above the 50th percentile. In a study by Nickel and colleagues (1982) of 25 children weighing less than 1360 grams at birth, full scale intelligence quotients as determined on the Wechsler Intelligence Scale for Children- Revised (WISC-R) were in the average range at 6.1 to 18.7 years of age with Verbal, Performance, and Full Scale scores of 94.1, 91.5, and 90.5, respectively.

Short term follow-up studies have shown also that VLBW and term-birth children have similar IQs. In a study of 16 VLBW children, Bennett et al., (1982) found that Stanford-Binet IQs were in the average range at age 3 with a mean of 106. Bayley Mental Development indices were also average for children in this study at the 6 to 30 month age range. Als et al., (1988) followed 112 preterm and 48 full-term babies. These investigators found that Bayley scores did

not differ between the two groups at 9 months of age, with all mean scores above 100. Marlow et al. (1987) followed 654 children weighing less than 2000 grams at birth to a median age of 3 years, 3 months. The mean Griffith Mental Development Scale and Wechsler Preschool and Primary Scale of Intelligence (WPPSI) overall quotients were 101.6 and 101.8, respectively. Greenberg and Crnic (1988) followed 30 preterm infants weighing less than 1801 grams at birth and found language and cognitive development to be adequate at 2 years of age. Mean Bayley scores for the VLBW sample of children were 99.4 and 103.8, respectively, for the mental and motor scales. Although results of these studies allow for the conclusion that VLBW children are comparable intellectually to full-term peers, other investigators have uncovered subtle differences between these two groups of children.

Learning Disabilities in VLBW Children

VLBW children have a higher incidence of problems than full-term children in the areas of visual-motor integration, attentional abilities, motor skills, language, and behavior. A follow-up study of 102 VLBW children at ages 4 to 8 revealed that 20.6% had possible learning disabilities as evidenced by average IQs and deficits in such areas as language comprehension and visual-motor integration (Hunt et al., 1982).

Hunt et al. (1988) examined 108 VLBW children at age 8 and evaluated 57 of these children again at age 11 using the Wechsler Intelligence Scale for Children-Revised (WISC-R), Bender-Gestalt Test, and Wide Range Achievement Test (WRAT). At age 8, 36.1% were classified as normal with no indications of learning difficulties. Visual-motor deficits were the most common difficulties exhibited by 21.4% of the VLBW children. Language and performance disabilities were each manifested by 12% of these children. Learning disabilities, defined as a 15 point discrepancy between Full Scale WISC-R score and one WRAT achievement subtest score, were found in 16.7% of all children at age 8. However, it should be noted that the children classified as learning disabled had a mean WISC-R score of 110.3 and regression to the mean could have accounted for some of the discrepancies observed (Reynolds, 1984). At age 11, similar results were obtained. Using the same criteria, approximately two-thirds of the VLBW children were classified as having mild to severe disabilities with 14.6 exhibiting signs of learning disabilities.

Siegel (1983) conducted a longitudinal study of 42 full-term children and 44 preterm children who had a mean birthweight of 1236 grams. At 5 years of age, children were evaluated using the Satz Battery (Fletcher & Satz, 1980). The Satz Battery consists of the Peabody Picture Vocabulary

Test (PPVT), Recognition Discrimination Task, Beery Visual Motor Integration Test (VMI), Alphabet Recitation, and Finger Localization. It has been shown to be predictive of reading problems when administered at age 5 (Fletcher & Satz, 1980). Siegel concluded that VLBW children are at risk for learning disabilities as evidenced by significantly lower scores on three of the five areas of the Satz Battery. The VLBW group of children obtained a VMI score of 89.6 while the full-term group of children obtained a score of 102. The group of VLBW children also obtained lower scores than the full-term group of children in the areas of Recognition Discrimination and Alphabet Recitation. Language comprehension as measured by the PPVT did not differ between the two groups.

Blennow and colleagues (1986) followed 45 ventilator-treated babies weighing less than 2500 grams at birth. Neurological examination and the Griffith Mental Development Scale administered at ages 6 and 7 revealed that 33% had attentional problems and 40% had locomotor and performance deficits. These deficits were not correlated with birthweight or duration of ventilator treatment. Visual-perceptual and visual-motor deficits were also apparent in this sample. The authors concluded that approximately one-third of low birthweight, ventilator-treated babies are at risk for later school difficulties.

Mazer and colleagues (1988) recently followed 78 infants weighing less than 1500 grams at birth to 3 years of age. Locomotor quotients on the Griffith Scales decreased over time from a mean score of 116 at 6 months to 98 at 36 months. The degree to which this decreasing pattern of motor scores continues into later childhood is unknown and is indicative of a need for longitudinal follow-up of VLBW children.

The above studies suggest that children born of very low birthweights are at risk for later learning disabilities. This risk appears to be greater for VLBW children than it is for their full-term peers and may involve problems in the areas of motor functioning, visual perceptual skills, language comprehension, and academic skills.

Early Processing Difficulties of VLBW Children

A recent study that included 160 newborns investigated 112 preterm and 48 full-term children to 9 months of age (Als et al., 1988). At 42 weeks postconception, the Assessment of Preterm Infant's Behavior (APIB) was administered. The APIB was developed to measure primarily the ". . . infants reactivity and threshold of disorganization and stress to environmental input" (Als et al., 1988, p.9). At 42 weeks postconception, preterm babies as a group were more disorganized and had lower stress

thresholds than full-term counterparts. This disorganization and vulnerability to stress increased with degree of prematurity. These differences existed in the preterm group of children even when social class was controlled statistically.

Infants in this study were later administered the Kangaroo Box (K-Box) paradigm at 9 months of age. The K-Box is a plexiglass box containing a wind-up kangaroo that is accessible only through a transparent mobile porthole latch-door (Als et al., 1988). In attempting to retrieve the kangaroo, the infant draws upon cognitive, motor, social, and affective capacities. The paradigm yields information about organizational abilities in children across several behavioral dimensions and is believed to correspond to parameters measured by the APIB.

At 9 months of age, preterm children as a group were significantly poorer than full-term children in fine motor organization, cognitive appreciation of the situation, affective response, attentional organization, pleasure and pride, combining social and object play, and overall competence. Earlier preterm children also had more difficulty with autonomic organization. Children who were disorganized on the APIB at 42 weeks postconception continued to be disorganized at 9 months on the K-Box paradigm. Although Bayley scores did not differ between the

groups of preterm and full-term children at 9 months of age, more preterm children were perseverative in their play, distractible, and disorganized in their approach to problem solving on the K-Box. The authors, following a synactive theory of development, concluded that the problems exhibited by many of the VLBW children were neurologically based and originated shortly after birth.

O'Reilly and colleagues (1986) followed 102 infants with birthweights less than 1500 grams to 9 months of age at which time the Bayley Scales, Gesell Developmental Schedules, and a range of motion test were administered. The infant's ability to habituate to environmental input during the neonatal period, as measured by the Brazelton Neonatal Assessment Scale, was correlated with the mental scale of the Bayley at 9 months of age ($r= -.73$). Additionally, habituation during the neonatal period was significantly correlated with the overall Gesell score ($r= -.52$). Ability to orient to incoming stimuli on the Brazelton during the neonatal period was also significantly related to the Bayley motor and mental scale scores and the Gesell gross motor scale score at 9 months of age ($r= .31$, $.44$, and $.28$, respectively). Family income was not an important predictor of outcome when variables were examined through multiple regression analysis.

Ruff (1986) found that preterm infants had less organized behavior than full-term infants in their approach to novel objects. She examined 41 children, 17 of whom had birthweights less than 1500 grams and 24 who were born full-term, at 30 to 32 weeks adjusted age. She found that the group of preterm children spent an average of 19.3 seconds examining novel objects compared to 55.4 seconds of examination by the full-term group of children. Latency time before examination of objects also differed significantly ($p<.01$) between the two groups with mean latency times of 10.6 seconds and 21.9 seconds, respectively, for the full-term and preterm groups of children. Additionally, full-term children generally approached objects in an organized manner by examining, then mouthing, and finally banging objects. Conversely, many of the preterm children did not display this organized approach. Rather, their behavior was observed to be less differentiated than that of the full-term group. Ruff concluded that preterm children have difficulties related to reactivity, sustained attention, and organization at approximately 7 months of age. The degree to which behaviors observed in these preterm children foreshadow later attentional and organizational problems has yet to be explored.

In a recent study, Cohen and colleagues (1988) examined 89 prematurely born children who were 8 years of age. The 22 of these children who were found to have learning problems were compared to the 67 without apparent learning problems. All children weighed less than 2500 grams at birth. Learning problems were defined as having a full-scale IQ score of 80 or above and either achievement below the 25th percentile on standardized mathematics or reading tests, retention or recommended retention, or special class placement. The overall rate of learning problems was 25% for this preterm group of children.

Although larger birthweight preterm children were included in this study, the increased risk status of preterm children for later school difficulties was apparent. The authors did not report the proportion of smaller preterm children who experienced learning problems at age 8. Therefore, it is unknown whether smaller preterm children in the study had learning problems at the same magnitude as larger preterm children. Demographic data components such as socioeconomic status were not predictive of learning problems in this study. Neonatal self-regulation behavior as measured by state organization (i.e. amount of active sleep) was predictive of outcome at age 8. Because active sleep has a distinct neurophysiological component in terms of organization, the authors suggest that the neonate's

abilities to organize states can provide information about possible later neurological difficulties in the areas of learning, attention, and organization.

The results of these studies indicate that VLBW children as a group have a higher rate of early processing difficulties than children born at term. Difficulties have been observed in the areas of organization, attention, habituation, orientation, and neonatal self-regulation. Researchers have suggested that these early processing difficulties may be predictive of later neurological problems.

Neurological Problems of VLBW Children

Other researchers have provided additional evidence of neurologically based differences in VLBW children, lending further support to Al's theory. Francis-Williams and Davies (1974) examined visual-motor integrative functioning in 65 VLBW children at ages 5 to 12 using the Bender Gestalt Test. Immaturity associated with neurological dysfunction (Koppitz, 1964) was apparent in their design reproductions, with 36 of the children scoring at least one standard deviation below the mean. Separations, rotations, and distortions were common in their designs.

In a study of 23 infants weighing less than 1001 grams at birth, it was determined that a longitudinal complications rate of 30% existed for children aged 18

months to 3 years (Driscoll et al., 1982). Neurological deficits were apparent in 17% of these children, although the authors were not specific about the nature of these deficits. Hertzig (1981) conducted an 8 year follow-up study of 66 children whose birthweights were between 1000 and 1750 grams. Neurological examination revealed that 50% of the sample had signs of neurological dysfunction at follow-up. Localized signs (i.e. signs associated with central nervous system dysfunction such as pathological reflexes) were found in 13 of the subjects. Two or more non-focal or "soft" signs (i.e. dysfunction in speech, balance, coordination, gait, sequential finger-thumb opposition, and muscle tone) were found in 20 of the subjects. Dysfunction was not associated with socioeconomic status.

Based on the above studies, it appears that differences between VLBW and full-term children may exist at a neurological level. These differences may emerge shortly after birth and continue throughout life. The synactive theory of development proposed by Als (1986) provides a basis for understanding the process by which these developmental differences might evolve.

Synactive Theory of Development

The central themes underlying the synactive theory of development are consistency of environmental interactions throughout life and predictability of behavior (Als, 1986).

Some researchers have maintained that newborns do not have the capacities or capabilities that are necessary in later childhood, thereby making prediction impossible except in extreme cases (Prechtl, 1984). Discontinuity of development is emphasized in this line of thought. Conversely, the synactive theory holds that the manner in which an infant interacts with the environment is predictive of later behavior. Als et al. (1988) state that ". . . an organism draws on all its capacities at all times in its developmental progression . . . [and] how well it does so is consistent over time" (p.4).

There are four principles that are incorporated into synactive developmental theory (Als et al., 1988):

(1) The first principle, species adaptedness, is based on the thesis that an organism at any stage of its development has become competent at that stage through evolution (Hinde, 1970);

(2) The principle of continuous organism-environmental interaction (Piaget,1952) is based on the premise that development occurs only through interaction with the environment;

(3) The underlying premise of the third principle, orthogenesis and syncresis, is that development proceeds toward increasing differentiation (Bruner, 1968; Piaget, 1952); and

(4) The principle of dual antagonistic integration is based on the thesis that an organism constantly strives for smooth integration by balancing approach and avoidance behaviors (Schneirla, 1965).

A central idea of synactive theory is that at each developmental stage, various subsystems exist side by side, occasionally interacting, but often in a sort of ". . . holding pattern as if providing a steady substratum for one of the system's differentiation process" (Als, 1982; p.230). At each developmental level, adaptation occurs only through an interplay between the environment and the primary developmental agendum that is determined by the subsystem in differentiation. The subsystems or developmental agenda emerge hierarchically in the order of autonomic, motor, state-organization, attention, and interaction. Development is sequential in that the infant must successfully master one level before entering the next. Movement to higher levels must occur in the background of well-integrated functioning at lower levels. Otherwise, the result will be distorted defense behaviors (e.g. averting gaze or closing eyes) caused by a discrepant organism-environment fit. A poor fit can lead to a cycle of increasing disorganization and distortion that may result in physiological changes in the developing brain (Als, 1986).

As an infant moves to a higher step of differentiation, synactive theory maintains that previous subsystems are temporarily disorganized. However, after the new developmental agendum has been mastered, subsystems realign at a higher level of differentiation, once again supporting each other. A higher level of differentiation cannot be attained if too much stress is present. Rather, a maladaptive realignment occurs that is costly to the infant's development. The result in this situation is rigid, less differentiated functioning and continued use of maladaptive strategies for dealing with environmental input.

Because development occurs through an interplay of sensory information and experience, the environment can either facilitate or hinder an infant's development (Als, 1985; Als et al., 1988). The result of this interplay is either "species appropriate ontogenetic integration patterns . . . [or] . . . deleterious adaptation patterns" (Als, 1986, p.4). A prematurely born baby is not programmed biologically to handle the extrauterine environment and is easily overloaded and stressed (Lawhon & Mazer, 1988; Linton, 1986). The premature infant's brain is overly sensitive and lacks necessary inhibitory mechanisms (Als, 1986). These infants should have 13 to 16 additional weeks in utero where physiological functions, diurnal rhythms,

muscle tone and movement are largely controlled by maternal factors. Instead, they are placed in environments to which they are poorly matched and where they are at increased risk for developing distortions and disorganizations that may lead to physiological changes in the developing brain.

The baby who is born prematurely is therefore at risk for developing later processing problems according to synactive developmental theory. The stresses that often result from a poor organism-environmental fit may lead to less differentiated functioning and changes in the developing brain of the prematurely born neonate. The result of these physiological brain changes may be long range processing difficulties.

Physiological Brain Development in VLBW Babies

Physiological development of the brain during the last trimester of pregnancy contributes to the premature neonate's problems with environmental adaptation. Brain cells, especially in the association areas, are rapidly emerging and differentiating from 26 to 40 weeks gestation. During the prenatal period, neurons in the brain emerge at a rate of 250,000 per minute (Thompson,1985). Preterm birth can have a major impact upon the developing brain.

Developmental distortions may result from active suppression or inhibition of normal brain pathways during sensitive periods as has been suggested by animal models

(Huble, Wiesel, & LeVay, 1977; Spinelli, Jensen, & DePrisco, 1980). These suppressions appear to be caused by endorphine mechanisms which are highly concentrated in association cortical areas of the brain, areas that have been associated with attentional, learning, and behavioral problems in school-aged children (Als, 1986). The premature neonate's brain lacks inhibitory mechanisms believed to be associated with differentiation of cortical association areas. Consequently, these babies may be unable to protect themselves from sensory input. While normal pathways are being suppressed, current functional pathways in the premature neonate's brain are being overactivated. The result of both processes, according to synactive theory, is less differentiated and less modulated behavior on the part of the baby.

The premature neonate's difficulties in processing information may also be influenced by myelination and neurotransmitters. The peak myelination time occurs at around 40 weeks gestation, the time of term birth (Volpe, 1981). Myelin speeds conduction of neural impulses and accommodates neuronal track growth. Lack of myelin in the premature neonate's brain could impact information processing and perhaps result in long term changes in processing functions of the brain.

The release of neurotransmitters is dependent upon other regulatory systems functioning properly in the baby and receptors for neurotransmitters are dependent upon experience. Other regulatory systems in the premature baby are often not functioning properly. Additionally, the experiences of the premature neonate are often not optimal because of the poor organism-environment fit. In summary, ". . . [T]he brain and sensory organs are continuously dependent on each other for normal structural and functional development . . . [I]t is potentially quite dangerous to be born before term" (Als, 1986, p.6). Researchers are just beginning to identify some of the subtle dangers to which Als was referring, dangers that could have an impact not only on a child's early development, but on later learning processes as well.

Premature birth can have an impact on the developing brain in several ways. Physiological changes could include inhibition of normal pathways and overactivation of functional pathways in the premature neonate's brain. Neurotransmitters and myelin also influence the premature neonate's ability to process information. These

physiological factors could result in long range processing difficulties.

Educational Needs of VLBW Children

Increasing numbers of VLBW children are now reaching school age. While these babies constitute only approximately 1.5% of all births, their disproportionate contribution to the number of children with neurodevelopmental handicaps causes them to be of concern to educators.

The chances of a VLBW baby surviving as a healthy, interactive infant tripled between 1960 and 1980 (Stewart, Reynolds, & Lipscomb, 1981). Major handicapping conditions such as cerebral palsy and mental retardation have not increased proportionately in VLBW survirors during this period (Drillien et al., 1980; Hunt et al., 1982). The incidence of such handicaps among VLBW infants has remained relatively stable at 6-8% (Stewart et al., 1981). However, VLBW children are 3 times more likely than full-term peers to develop later neurodevelopmental handicaps (McCormick, 1985) and one-third of VLBW children encounter academic difficulties by 7 years of age (Blennow et al., 1986).

The increasing number of VLBW children reaching school age and meeting with academic difficulties is a concern to educators. It becomes an issue of even greater concern when currently high drop-out rates are considered. Large

expenditures of money are being appropriated for drop-out prevention programs across the country. Because VLBW children are at risk for learning problems, they may consequently be at risk for dropping out of school. Although subtle learning difficulties have been identified in VLBW children, few studies have followed these children into elementary school. Organizational and attentional difficulties have been identified in infants born VLBW, but the extent to which these difficulties continue into school years is still unknown.

There is ample evidence to support the high risk status of VLBW children for later learning difficulties. The question of what can be done to reduce academic failure in these children is still unclear. Perhaps VLBW children have different processing functions than full-term counterparts because of, as Als suggested, underlying neurological differences that occurred shortly after birth. Knowledge of such processing functions could assist educators in developing appropriate teaching strategies to enhance learning in VLBW children. In order to plan effective strategies for these children, there is a need to determine whether weaknesses exist in coding processes, attentional processes, and/or organizational processes (Naglieri, 1988).

If children born with very low birthweights are found to have later organizational problems, this finding will not only have an impact on delivery of educational services, but will also have an impact on service delivery by professionals in the medical sector as well. Intervention strategies for promoting organization in neonates have been outlined by several researchers (Als, 1988; Lawhon & Melzar, 1988) and will have increasing relevance for nursing staff and early intervention specialists who work with VLBW babies and young children. If no differences are found between VLBW and full-term peers at 8 years of age in terms of organizational abilities, then perhaps some of the interventions being recommended for use in intensive care nurseries with these babies will need to be reexamined.

Identification of processing functions of VLBW children at school age may assist school psychologists in planning assessments for these children. Use of instruments sensitive to processing functions such as attentional processes, coding processes, and organizational processes may have increasing relevance for use with VLBW children if they are found to differ as a group from full-term children in these processing areas.

In this study, attempts were made to look at subtle cognitive processes rather than global intellectual functioning of VLBW children. Global IQs tend to mask

discrete differences in intellectual functioning, differences that can have a profound impact on learning ability (Aylward, 1988; Kaufman, 1988; Naglieri & Das, 1988). A broader assessment of cognitive functioning can be obtained by examining successive, simultaneous, attentional, and organizational processes (Nagieri & Das, 1988). The Cognitive Assessment System (CAS) developed by Naglieri and Das (1987) was used in this study to measure these four processes. In addition to providing a broader measure of cognitive processes, the CAS was developed to reflect a theory of information processing that is neurologically based. Therefore, performance on this instrument should provide information about neurological aspects underlying processing functions of VLBW children.

The PASS Model of Assessment

The PASS model of processing is an information-integration model first proposed by Das (1972) and later described by Naglieri and Das (1988). The Cognitive Assessment System (CAS) developed by Naglieri and Das (1987) follows the PASS model and is intended to measure planning, arousal, and coding functions. The authors based the model on the work of Luria (1973) who identified three functional brain units or blocks.

Luria’s Model of Information Processing

The first of Luria’s identified units is arousal. Arousal is the prerequisite for all mental processing because an optimal state of arousal is necessary in order for effective cognitive processing to occur (Das, 1984). An appropriate level of arousal allows an individual to direct attention toward relevant stimuli, direct attention away from irrelevant stimuli, and divide attention between activities without decreased efficiency (Naglieri, 1988).

The second functional unit proposed by Luria is coding. Coding is the cognitive function involved in receiving, processing, and storing information. Luria (1966) found strong evidence of simultaneous and successive processes within the coding unit of the brain. In simultaneous processing, each element o\f a stimulus is related to all other elements of the stimulus (Das, Kirby, and Jarman, 1975). Because all aspects of the stimulus are accessible during inspection, simultaneous activities are said to be surveyable. Luria stressed the importance of simultaneous processing in understanding relationships of any kind. Simultaneous processing is also required for solving matrices (Raven, 1956) and copying designs (Naglieri, 1988).

The other aspect of coding is successive processing whereby each element of a stimulus is related only to adjacent elements. In successive processing, stimuli are integrated into series and synthesized into a chain-like progression of elements (Das, 1973). Stimuli cannot be surveyed in successive processing tasks. Successive processing is especially important in learning skilled movements such as writing (Luria, 1966) and is involved in recalling series of words (Naglieri & Das, 1988). Simultaneous and successive processing are both involved in understanding statements and in reading comprehension (Das, Cummins, Kirby, & Jarman, 1979).

The last unit described by Luria is planning. Planning is the process that is responsible for ". . . programming, regulation, and verification of activity . . . " (Naglieri & Das, 1988, p. 38). It is described in Luria's approach as a process or function rather than an ability (Das, 1980). A planning test ". . . should indicate how the individual approaches a task, the strategies he uses to reach a solution" (Das, 1980, p.142). The planning function is used after information has been received, coded, and stored. The planning function is involved in formulating plans of action, regulating behavior so that it corresponds to plans, comparing results of actions to intentions, and correcting errors. The planning unit has been determined to be

responsible for complex functioning such as problem solving (Naglieri, 1988).

Although some amount of planning is necessary to execute coding processes, a separate planning factor is possible because variance could not be completely explained by coding tasks (Das, 1980). The independence of the three processes is assumed by Luria's theoretical model that suggests that independent areas of the cortex are responsible for coding and planning. The independence of coding and planning is not only supported by factor analytic studies, but by clinical work as well (Luria, 1973).

The three functional units of the brain have different underlying anatomical correlates (Luria, 1980). Arousal is located in the brainstem, diencephalon and medial regions while coding originates in lateral areas of the neocortex. Planning, the most complex form of human behavior, is primarily associated with the frontal lobes. Clinical studies of patients identified brain lesions have shown planning and coding to be clearly separate (Das, 1980). Individuals with frontal lobe damage have been found to have minimal problem with coding information, but have deficient planning processes. Those with damage to parietal, occipital, or temporal lobes typically have little problem with planning, but display deficits in coding processes. Popper and Eccles (1977) found prefrontal lobe damage to

result in problems performing tasks requiring flexibility and insight. Das (1980) suggests that good measures of planning will be able to discriminate between patients with and without frontal lobe lesions.

The three functional units, according to Luria (1973), are responsive to experiences of the individual and, therefore, are subject to developmental changes. Although distinct, the units continually interact with each other. Most traditional intellectual measures are focused only on one of the functional units proposed by Luria, the coding process. In other words, intelligence tests generally measure the ability to process information through sorting, storing, and retrieving information (Naglieri & Das, 1988). These instruments fail to measure one of the highest forms of human behavior- planning (Bracken, 1985; Naglieri, 1988). The Cognitive Assessment System is designed to provide analysis of all aspects of the PASS model and measures planning and arousal in addition to coding processes. The theoretical model underlying the instrument is complex, but this is considered by the authors to be one of the major strengths of the instrument (Naglieri, 1988).

The Cognitive Assessment System

Although the CAS is still in the developmental stage, its characteristics and technical qualities are sufficient to warrant inclusion in the present study. Extensive

efforts have been directed at developing the CAS and several studies have supported its validity. Naglieri (1988) evaluated the PASS model of assessment using six criteria proposed by Dillon (1986) and concluded that the model had the necessary characteristics to be considered potentially useful for assessing cognitive processing functions. The six criteria included validity, diagnosis, prescription, comparability, replicability/standardization, and psychodiagnostic utility.

Validity. The work of Luria (1966) provides evidence for three functional brain units that have underlying physiological correlates as has been previously discussed. Das (1973) later provided additional evidence for the existence of simultaneous and successive processes in a factor analytic study of cognitive tasks administered to groups of Canadian and Indian boys between the ages of 9 and 11.

In a factor analytic study of several cognitive tasks administered to 60 retarded and 60 nonretarded children, the successive and simultaneous factors emerged for both groups (Das, 1972). However, certain tests loaded differently between the two samples. For example, the Memory for Designs test was loaded on the simultaneous factor for the retarded group whereas it was loaded on the sequential factor for the nonretarded group.

Sequential and simultaneous processes were found to exist across age levels and socioeconomic levels in a study of 60 first grade and 60 fourth grade students (Molloy, 1973). A varimax rotation of nine tasks yielded three factors that were similar for both samples- successive, simultaneous, and speed. Similarly, the three factors emerged when the tasks were administered to 60 low socioeconomic status children and 60 middle-to-high socioeconomic status children, although slight disparities were noted. Visual short-term memory loaded on the successive factor for fourth grade children while it loaded on the speed factor for first grade children. However, varimax rotation assumes that underlying factors are independent and its use with mental tests may be inappropriate.

Successive and simultaneous processes have also been found to exist across cultures. Das (1973) administered six tasks to a group of 90 children from Orissa, India and found that the same three factors emerged. Likewise, similar factor structure resulted when 10 cognitive tests were administered to 40 native Canadian children in the third and fourth grades (Krywaniuk & Das, 1976). Simultaneous and successive coding processes also were identified in a group of 60 Indian children between the ages of 7 and 9 (Dash, Puhan, & Mahapatra, 1985). Simultaneous, successive, and

planning factors emerged in a factor analytic study of several cognitive tasks administered to a group of Chinese students, and each process was significantly related to reading achievement (Leong, Cheng, & Das, 1985).

The successive, simultaneous, and planning factors of the PASS model have been found to exist across ages. Naglieri and Das (1988) administered nine cognitive tasks to 149 second-grade students, 160 sixth-grade students, and 125 tenth-grade students. Orthogonal varimax and promax oblique rotations revealed that successive, simultaneous, and planning factors emerged at all three grade levels.

Using the same sample, Naglieri and Das (1987) found that successive, simultaneous, and planning factors changed with developmental level and chronological age and were related to achievement, lending support to the construct validity of the PASS model. The developmental nature of the model was apparent as raw scores significantly increased from grades 2 to 10 for those tasks where the score was the number of correct responses. Likewise, significant decreases were noted between the two grades for timed tasks. Evidence for criterion-related validity was provided through correlational analyses of processing composite scores and achievement scores on the Multilevel Academic Survey Test (MAST). The processing composite scores correlated significantly with scores on the MAST at each

grade level (r= .207 to .555), and planning-achievement correlations increased with age. Similar significant relationships and developmental trends were apparent in the coding-achievement correlations. Results allowed for the conclusion that both coding and planning functions were related to achievement and planning became more important with increasing age.

Successive and simultaneous processes were identified in additional studies and were found to be related to achievement. In a study of 99 fourth grade students, Kirby and Das (1977) found these processes to be correlated with reading achievement. Correlation coefficients ranged from r=.316 between successive processing and vocabulary to r=.507 between simultaneous processing and reading comprehension. Das and Cummins (1978), in a study of 52 educable mentally retarded adolescents, found that simultaneous processes were related to performance IQs on the WISC-R (r=.58) and WRAT arithmetic subtest scores r=.28). Successive processing scores were related to a reasoning task (r=.35) as well as WRAT spelling and reading subtest scores (r=.32 and r=.33, respectively). Early reading skills such as decoding have been shown to involve primary use of successive processing strategies while higher level skills such as reading comprehension draw largely on simultaneous processes (Das et al., 1979).

Ashman (1978), in a study of 104 eighth grade students, found two planning tasks, (i.e. trail-making and visual search), to load with other activities requiring planning such as planned composition and verbal fluency (Das, 1980). These two tasks did not load with successive processing tasks, (i.e. auditory serial recall, visual short-term memory, and digit span), or simultaneous processing tasks, (i.e. figure copying and memory for designs), suggesting that planning processes can be measured separately from coding processes. Similar results were obtained in a sample of 46 mildly retarded adults. Additionally, the same three factors emerged with a group of trainable mentally retarded subjects ranging from 12 to 22 years in age, although only two subtests from each of the three areas were administered.

The attentional component was only recently included in the PASS model and research was still being conducted on the validity and reliability of attentional tasks at the time of this study (Naglieri, 1988). Tasks similar to those described by Posner and Boles (1971) and Stroop (1935) have been explored for inclusion in the CAS and seem to be valid for assessing the attentional component (Naglieri, 1988).

Diagnosis. The inclusion of the planning and attentional components in the PASS model has resulted in its being a more sensitive and efficient diagnostic tool than traditional instruments (Naglieri, 1988). Use of successive

and simultaneous measures alone has been shown by investigators to be ineffective for identifying learning disabilities (Naglieri, 1985a; Naglieri & Haddad, 1984). Although reading disabled students perform similarly to non-disabled children on successive, simultaneous, and attention tasks, they perform similarly to retarded children in the area of planning (Naglieri, 1987). The omission of planning tasks from traditional measures such as the Kaufman Assessment Battery for Children (K-ABC) and the WISC-R causes these instruments to be insensitive to cognitive weaknesses (i.e. planning deficiencies) that may be associated with subtle learning problems (Bracken, 1985). Because the PASS model incorporates planning and attentional components, it provides a broader conceptualization of cognitive functioning and may therefore be more effective for diagnosing exceptional children (Naglieri & Das, 1988). Because the PASS model has a broader view of intellectual competence, it may also be likely to be more effective as a predictor of success in occupational or educational programs (Naglieri, 1988).

Prescription. The PASS model is a process model rather than an abilities model. While abilities stress capacities of the individual, a process model emphasizes the strategies that an individual uses. Examining processes rather than abilities can result in a better understanding of how

individuals perform tasks, knowledge of how to train them more successfully, and information about how to design more effective educational programs (Das et al., 1979). Training in successive and simultaneous coding processes has been shown to result not only in improvement in these processes, but in improved academic performance as well (Brailsford, Snart, & Das, 1984, Krywaniuk & Das, 1976). Although planning and attentional measures have not been included in these studies, the extent to which training in planning processes carries over into academic performance can be inferred from studies of metacognition training (Brown & DeLoache, 1978; Wellman, Fabricius, & Sophian, 1985).

Comparability. Processing measures must be related to a target task, and that is the case with the PASS model. By analyzing the structure of a task, the underlying cognitive processing component can be ascertained. The differences between the processing tasks of the PASS are obvious when components required for performance of each task are examined. For example, simultaneous processing tasks require the individual to relate parts of a task into groups where each element of a group must be considered in relation to all other elements of a group. In other words, all aspects of the task will be surveyable (Das et al., 1979). Successive processing tasks require the individual to observe the linear nature of stimuli and all aspects of the

task will not be surveyable (Naglieri, 1988). Attentional tasks require the individual to not only respond to a stimulus, but also to suppress reactions to irrelevant stimuli (Stroop, 1935). Finally, planning tasks require the individual to determine and use the most efficient way to solve a problem. Planning processes will underlie a task when ". . . the individual is required to analyze a task, develop a means of solving the problem, evaluate the effectiveness of the solution, modify the plan as needed, and demonstrate some efficient and systematic approach to problem solving" (Naglieri, 1988, p.18).

Replicability/Standardization. The value of a measurement system is increased when it can be organized into a consistent method and applied across examiners so as to allow for replication (Naglieri, 1988). Additionally, normative data for comparative purposes increases the value of a measurement system by reducing interpretation errors. Although the PASS model has not yet been standardized, the operationalization of the model has shown that replication is possible (Naglieri & Das, 1987; 1988). The Cognitive Assessment System, developed by Naglieri and Das (1987) and scheduled for publication in 1990, was designed to provide a standardized measure of planning, attention, and coding processes (i.e. successive and simultaneous processing).

Psychodiagnostic Utility. The psychodiagnostic utility of the PASS model has already been previously discussed. The utility of the model can be seen in the numerous studies that have used it across age ranges, exceptionalities, and cultures. Additionally, identification of children with learning disabilities may be accomplished more successfully with the PASS model than with traditional instruments because of its sensitivity to intellectual variability across processing functions. The degree to which diagnostic information obtained from the PASS model can be used for developing intervention strategies will require additional research. However, several studies have suggested that training in processing strategies can result in increased academic performance and improved use of cognitive processes (Brailsford et al., 1984).

Summary

Although VLBW babies constitute a small number of total births, these babies contribute disproportionately to the number of children with later neurological and developmental delays. While major handicapping conditions have not been demonstrated to have increased porportionately in the population of VLBW children with the increased survival rate, VLBW children appear to be at risk for later learning problems. Subtle handicapping conditions such as visual-motor delays, attentional deficits, organizational problems,

and motor delays have been found to occur more often in children born of very low birthweight.

Several researchers have suggested that the subtle problems exhibited by many VLBW children are caused by underlying neurological differences in this group of children. According to synactive developmental theory, VLBW babies are at risk for developing ". . . deleterious adaptation patterns . . . " (Als, 1986, p.4) because they are placed in environments that are poorly matched to their adaptation capabilities. This mismatch could lead to inhibition of normal pathways and overactivation of current functional pathways in the premature neonate's overly sensitive, immature brain, resulting in less differentiated and less modulated behavior on the part of the preterm infant. According to synactive theory, premature birth can be dangerous and lead to long lasting changes in the anatomy and function of the brain.

Increasing numbers of children born with very low birthweights are now reaching school age where a high percentage are encountering academic difficulties. The reasons for these learning problems have been difficult for researchers to identify. Although scores on global intellectual measures do not typically differ between VLBW and full-term children, a high percentage of VLBW children display indications of learning disabilities and subtle

developmental differences. Very low birthweight children tend to be less organized than full-term counterparts as neonates, with the disorganization continuing into infancy. The extent to which these organizational differences continue to persist at later ages has not yet been examined. The lack of longitudinal follow-up of VLBW children has led to difficulties in identifying the variables related to learning problems in this population. Knowledge of these variables could lead to more effective educational programming for VLBW children, more relevent psychological evaluations, and increased information about the risk status of VLBW children as suggested by synactive developmental theory.

In an attempt to identify underlying psychological processes that could affect academic functioning of VLBW children, the Cognitive Assessment System (CAS), based on the PASS model, was used in this study. The CAS was based in Luria's work and provides information on three functional processes of the brain: arousal or attention, coding (i.e. successive and simultaneous processing), and planning or organization. The CAS provides information on planning and attention, psychological processes that have traditionally been excluded from measures of intelligence. The CAS was administered to samples of VLBW and full-term children at 8 years of age. This age was selected for the purpose of

longitudinal data collection since at this age subtle learning difficulties usually become apparent to educators.

CHAPTER III

METHODOLOGY

It was the purpose of this study to examine the cognitive functions of VLBW children at 8 years of age. Rather than examining global intellectual functioning, it was the purpose of this study to investigate cognitive processing variables in VLBW children. It was proposed that identification of these variables would lead to more effective educational programming for VLBW children and, consequently, a decrease in their currently high risk status for educational difficulties.

The dependent variables in this study were those identified by Luria (1980)--specifically, attention processes, coding processes (i.e., simultaneous and successive processes), and planning processes. Data were collected on these variables using the Cognitive Assessment System developed by Naglieri and Das (1987). The independent variable in this study was birthweight.

For the purposes of presentation, this chapter has been divided into five sections. The sections are the description of the null-hypotheses, description of the

subjects, description of the research instrumentation, description of the procedures, and treatment of the data.

Research Hypotheses

The following null hypotheses were tested at the .05 level of confidence:

H1 There will be no statistically significant difference between the VLBW children and the full-term children in the mean organizational processing scores on the CAS.

H2 There will be no statistically significant difference between the VLGW children and the full-term children in the mean simultaneous processing scores on the CAS.

H3 There will be no statistically significant difference between the VLBW children and the full-term children in the mean successive processing scores on the CAS.

H4 There will be no statistically significant difference between the VLBW children and the full-term children in the mean attentional processing scores on the CAS.

Subjects

There were a total of 51 subjects selected for this study. The 21 experimental subjects included for the purposes of this study were all VLBW survivors treated at

Sacred Heart Hospital between the years 1979 and 1981 and who were 8 years of age at the time of the study. Sacred Heart is a regional Intensive Care Center (ICC) serving Pensacola and 17 rural counties in the northwest section of Florida referred to as the panhandle. Additionally, children from surrounding states (e.g., Alabama, Mississippi, and Georgia) are served by the center. Demographic characteristics of children born between the years 1979 and 1981 were unavailable. However, such information was available for all VLBW children treated at Sacred Heart's ICN between the years 1983 and 1988. It is likely that the demographic characteristics of children born between 1979 and 1981 were similar to children born during the 5 year period following 1983 (D. Goldberg, personal communication, April 3, 1989).

Between the years 1983 and 1988, a total of 669 VLBW babies were admitted to the Intensive Care Nursery (ICN) at Sacred Heart. Of these, 513 babies or 77% were discharged from the ICN. There was a 23% mortality rate for these infants during the neonatal period. The survival rate among these infants was similar to that reported by Hunt et al. (1982). The number of male and female VLBW survivors was approximately the same (i.e. 49% male and 51% female). There was a larger percentage of black VLBW survivors than was reported by McCormick (1985) with black VLBW babies

constituting 42% of all VLBW babies in the group of VLBW survivors. The percentage of Hispanic and other races was less than 1%. Approximately half of the group of VLBW survivors were of low socioeconomic status, as 55% received some medicaid services at the time of birth. Medicaid eligibility was unknown for 6% of the group and the remaining 39% had private insurance.

Experimental Subjects

The 21 VLBW subjects selected for the purposes of the study were demographically similar to the population of VLBW children treated and discharged from Sacred Heart's ICN between the years 1983 and 1988. There was a slightly higher percentage of males in the subjects selected than was found in the population of VLBW children treated at Sacred Heart during these years. The subjects selected consisted of 57% males and 43% females while the population consisted of 49% males and 51% females. The percentages of black children were similar between the two groups- 43% for the subjects selected and 42% for the population. Children of races other than white or black constituted less than 1% of the population and were not included in the sample of subjects selected. The mean age of the VLBW group of children was 8 years, 8 months.

The VLBW subjects selected contained fewer low socioeconomic children than were found in the population. Attempts to locate children who were in this category were often unsuccessful. Many parents of those VLBW children who could be located either did not respond or refused to participate. The subjects selected consisted of 33% of the children whose mothers were of lower socioeconomic status at the time of birth. Lower socioeconomic children constituted 55% of the population. Thus there was 22% underrepresentation of low SES children in the sample for this study. The remaining 67% of the VLBW sample were considered to be from middle to upper income families at the time of birth.

Control Subjects

A control group of 30 children was selected for this study. The mean age of the control group of children was 8 years, 6 months. The control group consisted of 63% white children and 37% black children. The percentages of male and female children in the control group were approximately the same as 53% of the group were male and 47% were female. Approximately one-third of the sample of children were of lower socioeconomic status at the time of birth while the remaining 67% were of middle to upper socioeconomic status at the time of birth.

Sampling Procedures

A sample of 21 VLBW children were selected from all VLBW babies treated in the Intensive Care Nursery at Sacred Heart Hospital between July of 1979 and July of 1981. Attempts were made to obtain a sample of VLBW children that was representative of all VLBW children admitted and discharged from Sacred Heart's ICN during the years 1979-1981 in terms of gender, race, and socioeconomic status. All VLBW children selected were 8 years of age at the time of the study with the exception of one child who was 9 years, 2 months of age. Children born with obvious anomalies or chromosomal abnormalities were excluded from the study. None of the children included in the study had been diagnosed with fetal alcohol syndrome at birth. Additionally, children who were attending classes for mentally handicapped students and children with severe behavioral problems were excluded from the study.

Because norms were not yet available for the Cognitive Assessment System and in order to provide a group of full-term children for comparison, 30 full-term children currently residing in the Pensacola area were selected for participation in the study. A stratified sample of full-term children was selected so as to match the VLBW sample of children in terms of age, gender, race, and socioeconomic status. The sample was stratified in that specific numbers

of children were selected in each of the demographic categories for inclusion in the control group of children.

The first step in obtaining a stratified sample of control subjects involved determining the percentages of VLBW children constituting each demographic category. These percentages were then used to determine the number of full-term children that would be needed in each demographic category. Attempts were then made to select full-term children in a manner so that percentages of children in each demographic category were similar to those of the experimental group. Children in the control group had birthweights of at least 2500 grams, were free from obvious anomalies and chromosomal abnormalities, and were not attending classes for mentally handicapped students.

The VLBW sample of children was selected by examining hospital records from the years 1979 to 1981. Addresses and phone numbers from these records were cross-checked with data in developmental follow-up records and phone books. Parents were contacted by mail, informed of the nature of the study, and asked to participate (Appendix A). Additionally, they were asked to complete a form requesting demographic information (i.e. maternal education, birthdate of child, and race of child) (Appendix B). Finally, they were asked to complete permission forms allowing their child to participate in the study (Appendix C). Materials were

sent to parents of all VLBW children for whom current addresses could be determined. All children whose parents granted permission for participation in the study were included in the VLBW sample of children.

Children in the control group were drawn from three sources--siblings of children enrolled in the developmental follow-up program at Sacred Heart, children of hospital employees, and children enrolled in the public schools. These children were selected so as to resemble the VLBW group of children in terms of age, race, gender, and socioeconomic status. Children were located by examining developmental follow-up records and through a notice posted in the hospital newspaper requesting volunteers for the study. Principals of local public schools assisted in locating some of the children for the study.

When a child was located who had the necessary demographic characteristics for inclusion in the study, parents were contacted by phone, informed of the nature of the study and asked if they would participate. Parents who expressed interest were then mailed letters explaining the nature of the study (Appendix A). They were also asked to complete demographic information and permission forms (Appendices B and C). All children whose parents granted permission were included in the study. Children were selected in this manner until 30 children were found who

closely resembled the VLBW group of children in terms of age, race, gender, and socioeconomic status.

Parents who granted permission for their child to participate in the study were mailed a letter thanking them for participating and notifying them of their appointment time (Appendix D). They were asked to return the letter indicating whether they could participate during that time or whether other arrangements needed to be made. Parents who needed to reschedule were contacted by phone to arrange a more convenient time.

Comparison of Groups

The control group of full-term children was quite similar to the VLBW sample of children in terms of age, race, gender, and socioeconomic status. Demographic characteristics of the two groups of children are depicted in Table 3-1. The VLBW group of children contained slightly higher percentages of black children and male children than the full-term group of children. However, these differences were minimal. The mean ages of the two groups were similar. The mean age of the term-birth and VLBW groups of children were 8 years, 6 months and 8 years, 8 months, respectively. The incidence of learning disabilities was also similar in both groups of children, but the control group had a slightly higher incidence. The incidences of identified learning disabilities in the term-birth and VLBW

groups of children were 6.5% and 4.5% respectively. There were two children identified as learning disabled in the control group and one in the experimental group. The incidence of identified gifted children was also similar between the two groups of children. There was one child identified as gifted in the experimental group while there were two in the control group. Corresponding percentages of gifted children in the experimental and control groups were 5% and 6%, respectively.

Table 3-1. Demographic Characteristics of VLBW and Full-Term Samples of Children

	VLBW Group	Term Group
White	57% (N=12)	63% (N=19)
Black	43% (N=9)	37% (N=11)
Male	57% (N=12)	53% (N=14)
Female	43% (N=9)	47% (N=16)
Low SES	33% (N=7)	33% (N=10)
Middle-High SES	67% (N=14)	67% (N=20)
	21	30

Because slight differences were found to exist between the VLBW and full-term groups of children, a decision was made to covary on three variables--child's age at the time

of testing, maternal age at the time of birth, and maternal education at the time of birth. Although the differences were not statistically significant, the use of these three variables as covariates strengthened the study by providing greater statistical power. The VLBW group of children was slightly older than the full-term group of children. Maternal age and educational level at the time of birth were slightly higher for the full-term group. Mother's educational levels were divided into four levels. Level one included those with less than a high school education while level two mothers had graduated from high school. Mothers with some college education or technical training fell into level three while level four mothers were college graduates. Means and standard deviations of these variables may be located in Table 3-2.

Adequacy of Sample Size

The sample sizes used in the study were small and may be construed to serve as a limitation of the study. Small sample sizes have often been a problem with studies of VLBW children, particularly those studies that are longitudinal in nature. The present study was an improvement over previous studies of VLBW children that used even smaller sample sizes (Bennett et al., 1982; Ruff, 1986). In order to minimize problems created by small sample sizes, a control group was selected that was demographically similar

to the experimental group in this study. Additionally, the use of covariates in the data analysis further minimized any group differences, thereby strengthening the design of the study.

Table 3-2. Distributional Characteristics of Covaried Variables for Full-Term and VLBW Samples of Children

Variable	Group	Mean	Standard Deviation
Child's Age	Term	101.97mos.	7.06mos.
	VLBW	104.29mos.	6.40mos.
Maternal Age	Term	27.47yrs.	5.22yrs.
	VLBW	27.33yrs.	5.69yrs.
Maternal Education	Term	2.87	.78
	VLBW	2.81	.87

Research Instrument

Children were tested individually using the Cognitive Assessment System (CAS). The CAS is an individually administered test of cognitive processes for children between the ages of 5 and 18. At the time of the study, the CAS consisted of 16 subtests, four each for the areas of attention, successive processing, simultaneous processing, and planning. The test required approximately 2 hours to administer. Directions for administration were included in the manual.

Validity

Although the CAS was still being developed at the time of the study, the 16 subtests had been shown to be adequately valid for research purposes. Therefore, permission was granted by the Psychological Corporation for use of the CAS in the current study. The construct validity of the CAS subtests has been repeatedly shown (Ashman, 1970; Das, 1980; Leong et al., 1985; Naglieri & Das, 1987; 1988). Ashman (1978), in a study of 104 eighth grade students, established construct validity for two of the planning tasks of the CAS. Naglieri and Das (1988) and Leong et al., (1985) established the construct validity of the successive, simultaneous, and planning tasks through factor analytic studies.

The developmental nature and criterion-related validity of the CAS subtests were shown in a study by Naglieri and Das (1987). Cognitive Assessment System subtests were correlated with scores on the Multilevel Academic Survey Test (MAST). Correlation coefficients ranged from $r=.207$ to .555 with planning-achievement correlations increasing with age. Other studies have allowed for the conclusion that the CAS coding subtests are correlated with achievement (Das & Cummins, 1978; Kirby & Das, 1977).

Studies were being conducted by the Psychological Corporation on the attentional component of the CAS at the time of this study (J. Sugarman, personal communication, February 3, 1989). However, construct validity for some of the CAS attention items has been previously established (Posner & Boles, 1971; Stroop, 1935). Preliminary research findings involving the attention subtests have allowed for the conclusion that they are valid (Naglieri, 1988).

Reliability

Studies on the reliability of the CAS were being conducted through the Psychological Corporation at the time of the study (J. Sugarman, personal communication, February 3, 1989). However, preliminary research findings have shown that administration of the CAS subtests across examiners is possible (Naglieri & Das; 1987; 1988). Because interrater reliability had not been established at the time of the study, three interrater reliability checks were made during the study. Two of these reliability checks were made with VLBW subjects and one was made with a control subject. The checks were made at 2-week intervals. While the examiner administered and scored the CAS, a second trained examiner observed the administration and scored the protocol. The two protocols were then examined for interrater agreement. There was 99% or better agreement on all three interrater checks, suggesting that

interrater reliability exists for the CAS. Test-retest reliability of the CAS had not been established at the time of the study.

Subtests of the Cognitive Assessment System

The 16 subtests, four each for the areas of planning, successive processing, simultaneous processing, and attention were as follows:

1) Visual Search. In performing this subtest, the individual was required to point to an object or letter surrounded by numerous objects or letters. The score was the time required from initial exposure of the stimulus to the point where the individual identified the target object or letter. This task was shown to load on a planning factor (Das, 1984; Naglieri & Das, 1987; 1988).

2) Planned Codes. The individual was required to code a series of boxes labelled with the letters A, B, C, or D using sequences of X's and O's given in the example (i.e. A=OX, B=XX, etc.). There were two items in this section, each having different codes and arrangements. The child was asked to code the boxes as quickly as possible. The score was the number of boxes correctly coded within the given time limits. This task was shown to load on a planning factor (Naglieri & Das, 1988).

3) Planned Connections. In this subtest, the subject was required to connect numbers located in boxes in correct numerical order. The numbers were randomly distributed on the page and the score was the time required to complete the task. In performing more advanced items on this subtest, the individual was required to shift between connecting numbers and letters in ascending or alphabetical order. Tasks similar to those on this subtest have been used by Reitan (1955) and Spreen and Gaddes (1969) and were originally part of the Army Individual Test of General Ability (1944). Armitage (1946) found that this task measured planning because it required the individual to organize a double relationship, avoid perseveration, and shift between rules. Das (1984) and Naglieri and Das (1987; 1988) found that trailmaking tasks loaded on a planning factor.

4) Matching Numbers. The subject was required to locate and circle two numbers that were identical. The length of the numbers ranged from one to six digits and the score was the correct number of pairs circled in three minutes. This

subtest was found to load on a planning factor (Naglieri & Das, 1987; 1988).

5) Design Construction. The individual used blue and white chips to construct abstract designs located in a stimulus book. The score was the number of designs successfully constructed within the specified time limits. This task was shown to load on a simultaneous factor (Das & Naglieri, 1989).

6) Simultaneous Verbal. The individual's task was to listen to a question read by the examiner and then choose the corresponding picture among six options that answered the question. The questions were printed at the bottom of each page and involved logical-grammatical relationships. This task was shown to load on a simultaneous factor (Das & Naglieri, 1989).

7) Figure Memory. Designs ranging in difficulty from a simple square to an open book design were embedded in a complex background. The individual was required to find a specific design and trace it with a marker. If all components of a design were traced by the individual, the item was passed. This subtest was shown to load on a simultaneous factor (Naglieri & Das, 1987; 1988).

8) Matrices. This subtest consisted of the Matrix Analogies Test- Short Form (Naglieri, 1985b). The score was the number of matrices successfully solved. This subtest was composed of 34 items similar to those on the Raven's Coloured Progressive Matrices Test (Raven, 1956). The Raven's Test was shown to load on a simultaneous factor (Das et al., 1979). Similarly, this subtest of the CAS was shown to load on a simultaneous factor (Naglieri & Das, 1987; 1988).

9) Word Series. This subtest included nine single syllable words that were presented orally. The words were of high familiarity and varied from two to nine words in length. The individual was required to repeat the words in the same order presented. The score was the number of items successfully repeated. This subtest was shown to load on a successive processing factor (Das et al., 1979; Naglieri & Das, 1987; 1988).

10) Sentence Repetition and Questions. This subtest contained two parts. In the first part, the individual was required to repeat sentences spoken by the examiner. In the second part, the individual was required to answer a question

about each sentence as it was again spoken by the examiner. Color names were substituted for content words in the sentences in order to minimize contexual cues (e.g. Blue gave the red a black). The score was the number of sentences correctly repeated and the number of questions successfully answered. This task was shown to load on a successive factor (Das & Naglieri, 1989).

11) Color Ordering. This subtest requires the individual to turn a series of colored chips in the same order demonstrated by the examiner. The chips were arranged linearly on a small board and were arranged in the sequence indicated in the manual. The subtest was designed to measure the individual's ability to reproduce the order of an event and was found to load on a successive factor (Naglieri & Das, 1987; 1988). The score was the number of items correctly performed.

12) Successive Hand Movements. This subtest was similar to that used on the K-ABC (Kaufman & Kaufman, 1983). However, it differed in that six hand movements were used rather than the three used on the K-ABC. In performing items on this subtest, the individual was required to reproduce series of hand movements demonstrated by the

examiner. The score was the number of items successfully performed. This subtest was found to load on a successive factor (Naglieri & Das, 1987; 1988).

13) Expressive Attention. This subtest consisted of three parts. In the first part, the child read color words as quickly as possible. In the second part, the child named colors as quickly as possible. In performing the third part, the child was required to attend to relevant stimuli while suppressing irrelevant stimuli by stating the inconsistent color that each color word was printed in. The score was the time required to complete the third part of this subtest. This task was shown to load on an attention factor (Das & Naglieri, 1989).

14) Receptive Attention. This subtest consisted of two parts. In the first part, the individual was required to find and underline pairs of letters that were the same physically. In the second part, the individual was required to find and underline pairs of letters that had the same name. The score was the number of pairs correctly located on both sections within the

given time limits. This subtest was shown to load on an attention factor (Naglieri, 1988).

15) Auditory Selective Attention. The individual was required to listen to a 5 minute tape and identify target words from a group of stimulus words. The individual was asked to tap the table each time a man said certain stimulus words and a woman said other stimulus words. This task required the individual to attend to relevant auditory stimuli while suppressing irrelevant auditory stimuli and was shown to load on an attention factor (Das & Naglieri, 1989). The score was the number of stimulus words incorrectly identified subtracted from the number correctly identified. If a child incorrectly identified more words than were correctly identified, a zero score was given.

16) Number Finding. The individual was required to locate and underline specific target numbers within a page of numbers that contained both the targets and distractor stimuli. The score was the number of numbers correctly located. This task was shown to load on an attention factor (Das & Naglieri, 1989).

Rationale

The CAS was selected over other instruments for use in this study because it provided a broader measure of cognitive functioning than traditional intellectual measures could provide. Because global intellectual measures have typically not been effective for examining differences between VLBW and full-term children, an instrument more sensitive to distinct cognitive processes was needed. The CAS was chosen because it provided measures in four cognitive processing areas (i.e. planning, simultaneous processing, successive processing, and attention). Traditional intellectual assessments have not included the planning and attention components; components that are crucial to examine in VLBW children in light of synactive developmental theory.

Assessment Procedures

Each child was tested individually and required approximately two hours to complete the CAS. Breaks were provided as needed to participants, usually half way through the evaluation (i.e. after the Matrices subtest). Most testing was conducted in a room free from distractions at the Children's Developmental Clinic located at Sacred Heart Hospital. Parents were asked to transport their children to the clinic for testing, but children were examined without their parents present. Parents who could

not transport their children to the clinic were asked to meet the examiner at a more convenient location, usually a nearby school. All testing was conducted by a trained examiner who attended a one-day training workshop conducted by the Psychological Corporation. The examiner was a certified, experienced, and licensed school psychologist who demonstrated proficient ability in administering the CAS prior to evaluating children in this study. Subtests were administered in the order specified in the CAS manual. Additionally, subtests were administered according to directions specified in the manual. Parents were given generally feedback about their child's performance aafter testing (i.e. attention span and cooperation).

Data Analysis

Distributional characteristics of all variables were examined first. These included the mean, standard deviation, mode, median, kurtosis, and skewness of each variable. All variables were found to have the necessary characteristics for the chosen data analyses (i.e. normal distributions and homogeneous variances). In examining the four null-hypotheses, mean subtest scores were compared between groups across the four areas of the CAS using multiple analysis of covariance (MANCOVA). Because normative data were not yet available for the CAS at the time of the study, raw scores were converted to z-scores

across the 16 subtests for the full-term group. Raw scores were then converted to z-scores for the VLBW group using this z-distribution. Area aggregate z-scores were calculated by summing the scores of the four subtests within each of the four areas of the CAS. Multiple analysis of covariance was conducted on the resulting four aggregate cluster scores to determine whether significant differences existed between groups ($p<.05$).

In order to control for initial group differences, three covariates were entered into the analysis: age of child at the time of testing, maternal age at the time of birth, and maternal education at the time of birth. Although attempts were made to equate the two groups on these three variables, it was found that slight differences existed. The use of these variables as covariates decreased the influences that they might have had on the results of the analysis.

Results of the MANCOVA yielded a significant F-value. Therefore, subsequent univariate F-tests were performed to determine which of the CAS area scores differed significantly between the two groups of children ($p<.05$).

Methodological Limitations

There were a few methodological limitations in this study that should be mentioned. First, the CAS was not completed at the time of the study. The instrument that

was used in this study will, in all probability, differ from the final version of the instrument. For example, the final version will include only 12 subtests rather than the 16 subtests that it contained at the time of the study. Additionally, individual items could change before the final version of the CAS is published. While it would have been better to have the final version of the instrument, the items and subtests in the experimental edition of the CAS had been shown to measure the processes that the test was designed to assess (Naglieri & Das, 1987; 1989). Therefore, the test was considered to be adequate for examining the processing functions of interest. Additionally, it was thought to be an improvement over traditional instruments that have been used in studies of VLBW children because it provided a broader view of cognitive functioning (Naglieri, 1988).

Related to this limitation was the fact that all children were tested by a single trained examiner. Therefore, the possiblility of experimenter bias effect was present. To minimize this problem, children were scheduled several weeks in advance in hopes of reducing any association of child's name with group membership. However, the experimenter was sometimes aware of the group membership of the children because of the extreme difficulties encountered in locating VLBW children. Also,

parents accompanied their children to the test situation and often talked spontaneously about their nursery experiences. The fact that the CAS is an objective instrument also served to minimize experimenter bias.

Another potential limitation of having a single examiner involved the reliability of scoring. Because the CAS is a new instrument, the degree to which reliable ratings could be given to responses was uncertain. However, the three interrater reliability checks that were performed throughout the course of the study should have minimized this limitation.

Another limitation related to the use of the CAS in this study was the lack of normative data. Although it would have been better to have large-scale normative data against which to compare the performance of VLBW children, the provision of a demographically similar control group of full-term children should have minimized this limitation (Borg & Gall, 1983, Kitchen et al., 1980).

The fourth limitation of this study was related to medical advances that have occurred over the past decade. The degree to which results of this study can be generalized to VLBW children born today is questionable due to rapid advances in medical technology. Advances in medical technology are always a problem with follow-up studies of VLBW babies. Nevertheless, the importance of

studies of VLBW babies. Nevertheless, the importance of following VLBW babies has been repeatedly stressed in the literature and the fact that medical technology is continually changing does not subsume the need for continued longitudinal studies (Als et al., 1988; Hunt et al., 1982).

A fifth limitation involved the lack of early relevant data on VLBW children that might be predictive of outcome. Although data such as days on oxygen, length of hospital stay, Apgar scores, and socioeconomic status were available, such variables have not typically been predictive of outcome. Although some studies have enabled the determination to be made that maternal education and other indicators of SES predict outcome of VLBW children (Chamberlin,1987; DeHirsch, Jansky, & Langford, 1966; Lasky et al., 1987), others have failed to substantiate such findings (Als et al., 1988; Cohen et al., 1988; Drillien et al., 1980; Hertzig, 1981; O'Reilly et al., 1986). Rather, it appears that more subtle, neurological early indicators (i.e. habituation to novel stimuli, state-organization, attentional processes) may be the best predictors of outcome (Als et al. 1988; Cohen et al., 1988). Unfortunately, such information is lacking in the current study.

Finally, the population of VLBW children from Sacred Heart's ICN was not entirely representive of VLBW children nationwide. There was a lack of children from major metropolitan areas as well as Hispanic children. Additionally, the sample of VLBW children selected for this study had fewer low socioeconomic children than had been found in the population of VLBW children nationwide. The degree to which results obtained in this study are generalizable to VLBW children in other samples will depend partly on the demographic make-up of VLBW children in other areas of the country. However, the use of neurologically-based assessment procedures in this study rather than global intellectual measures should have minimized the effects of socioeconomic status and race on test performance because cognitive processes rather than abilities were examined.

CHAPTER IV

RESULTS

The purpose of this study was to examine cognitive processing functions of very low birthweight children at 8 years of age. The processing functions examined were those measured by the Cognitive Assessment System--organization, simultaneous processing, successive processing, and attention. Results of statistical analyses are presented in this chapter.

Experimental Results

Mean raw scores for each of the four areas of the CAS could not be compared because of differing subtest scales. For example, some subtest scores were reported in terms of time taken to complete a task while others were determined by number of correct responses. Mean raw scores of the two groups of children for the 16 subtests are reported in Table 4-1. Inspection of subtest raw scores revealed that the VLBW sample of children obtained lower scores than the term-birth group of children in all 16 subtests of the CAS. Subtest raw scores could not be combined into area scores without first converting them to z-scores. After the z-score transformations were performed, subtest z-scores were added to obtain aggregate area scores for

Table 4-1. Comparison of CAS Subtest Raw Scores of Term-Birth and VLBW Children.

Subtest	Group	Mean Raw Score
1. Visual Search	Term	121.17 seconds
	VLBW	150.80 seconds
2. Planned Codes	Term	42.57 correct
	VLBW	35.52 correct
3. Planned Connections	Term	264.67 seconds
	VLBW	346.62 seconds
4. Matching Numbers	Term	16.87 correct
	VLBW	15.43 correct
5. Design Construction	Term	6.97 correct
	VLBW	5.86 correct
6. Simultaneous Verbal	Term	16.50 correct
	VLBW	16.33 correct
7. Figure Memory	Term	8.67 correct
	VLBW	7.95 correct
8. Matrices	Term	9.68 correct
	VLBW	9.48 correct
9. Word Order	Term	10.60 correct
	VLBW	10.24 correct
10.Sentence Repetition	Term	15.93 correct
	VLBW	13.62 correct
11.Color Ordering	Term	9.10 correct
	VLBW	8.29 correct
12.Hand Movements	Term	5.13 correct
	VLBW	4.48 correct
13.Expressive Attention	Term	85.63 seconds
	VLBW	94.38 seconds
14.Receptive Attention	Term	59.10 correct
	VLBW	54.38 correct
15.Auditory Selective Attention	Term	23.77 correct
	VLBW	11.05 correct
16.Number Finding	Term	50.03 correct
	VLBW	44.19 correct

statistical comparison. Area scores were compared using a multiple analysis of covariance (MANCOVA).

In this study, four null-hypotheses were proposed to examine processing functions of VLBW children. The processing functions of interest were organization, simultaneous processing, successive processing, and attention. The organization cluster was composed of the first four subtests of the CAS (i.e. visual search, planned codes, planned connections, and matching numbers). The simultaneous cluster was composed of the next four subtests of the CAS (i.e. design construction, simultaneous verbal, figure memory, and matrices). The next four subtests of the CAS, word order, sentence repetition, color ordering, and hand movements, comprised the successive cluster score. The attention cluster score was determined by the last four subtests (i.e. expressive attention, receptive attention, auditory selective attention, and number finding). A multiple analysis of covariance was used to compare area z-scores of the full-term and VLBW groups of children across the four areas of the CAS. Three variables, child's age at the time of testing, maternal age at the time of birth, and maternal education at the time of birth, were entered as covariates in the analysis to control for pre-experimental differences between groups.

Multivariate analysis revealed the presence of significant differences ($F=1.9$, $p=.041$). Therefore, subsequent univariate F-tests were performed to determine which variables the two groups differed on. Results revealed significant group differences in three areas of the CAS. Distributional characteristics of z-scores for the four areas of the CAS and results of the multiple analysis of covariance may be located in Table 4-2.

The MANCOVA procedure yielded an F-value of .36 ($p=.78$) for the organization cluster. Because the F-value of .36 was not significant at the .05 level, the first null-hypothesis could not be rejected. Organization scores of the two groups of children did not differ at the .05 level of significance.

Table 4-2. Comparison of CAS Area Scores of Term-Birth and VLBW Children and Results of MANCOVA.

Variable	Group	Mean	Standard Deviation	Univariate F-Value	p
Organization	Term	.001	1.58		
	VLBW	.574	1.56	.36	.780
Simultaneous	Term	.000	2.86		
	VLBW	-1.105	3.32	2.90	.045*
Successive	Term	.001	2.62		
	VLBW	-1.480	2.78	3.05	.039*
Attention	Term	-0.069	2.015		
	VLBW	-1.550	2.47	4.47	.008*

*p<.05

In the area of simultaneous processing, significant differences were found to exist betweeen groups. The MANCOVA was performed with an obtained F-value of 2.9 ($p=.045$). Consequently, the second null-hypothesis was rejected because the obtained F-value of 2.9 was significant at the .05 level. Inspection of group means revealed that the VLBW group scored significantly lower than the full-term group in the area of simultaneous processing.

Scores in the area of successive processing also differed between the two groups of children. Multiple analysis of covariance yielded an F-value of 3.05 ($p=.039$). Because the F-value of 3.05 was significant at the .05 level, the third null-hypothesis was rejected. The two groups differed in the area of successive processing. Inspection of group means enabled the investigator to determine that the VLBW group scored significantly lower than the full-term group of children in this area.

Finally, scores in the area of attention were found to differ between the two groups of children. Multiple analysis of covariance resulted in a significant F-value of 4.47 ($p=.008$). Because this F-value was significant at the .05 level, the fourth null-hypothesis was rejected. Inspection of group means revealed that the VLBW group

scored significantly lower than the full-term group in the area of attention.

Summary

Four hypotheses were tested using multiple analysis of covariance. The results of the MANCOVA procedure were discussed in this chapter for each of the four dependent variables investigated in this study. Significant group differences were found between the full-term and VLBW groups of children in the areas of simultaneous processing, successive processing, and attention, with the VLBW children scoring significantly lower as a group in each of these three areas. Scores in the area of organization did not differ significantly between the two groups of children. Therefore, children born of very low birthweights were found to have more difficulties than full-term children at 8 years of age in three of the four processing functions examined in this study.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to examine cognitive processing functions of VLBW children at 8 years of age. The processing functions examined were those proposed by Luria (1973); specifically, organization, simultaneous processing, successive processing, and attention. The Cognitive Assessment System was used to measure these four dependent variables. Area scores were compared between groups of VLBW and full-term children using a multiple analysis of covariance procedure. This chapter includes a discussion of generalizability limitations, evaluation of research hypotheses, conclusions, implications, and recommendations for future research.

Generalizability Limitations

There were several limitations to this study that could affect the generalizability of results. One limitation was related to the small sample sizes used in this study. Although larger samples would have been desirable, the sizes of those obtained were adequate for the number of dependent variables examined in the study and the statistical procedures used. Attempts were made to strengthen the design by selecting a control group that was

demographically similar to the VLBW group of children in terms of age, race, gender, and socioeconomic status. Consequently, the problems created by small sample sizes were partially controlled by selecting demographically similar groups of subjects. Additionally, covariates were used in the data analysis to control for any pre-experimental group differences between groups. However, other variables were not controlled and could have been a source of variance in the present study. Information was not available on the learning experiences of the children (i.e. enrollment in early intervention programs, teachers, schools). Knowledge of these variables would have strengthened the design of this study. It should also be mentioned that small sample sizes are frequently a problem in studies involving long-term follow-up of VLBW children. The current study was an improvement over previous follow-up studies that used even smaller sample sizes (Bennett et al., 1982; Ruff, 1986).

A second limitation to the present study that affects generalizability of results involved the nature of the samples obtained. The VLBW group of children obtained in the current study was not representative of the population of VLBW children. The VLBW sample of children contained fewer low socioeconomic children than would be found in the general population of VLBW children. It was difficult to

locate these children and many of the parents of children who could be located either did not respond or refused to participate. It is unknown if parents who agreed to participate differed from those who could not be located, did not respond, or refused to participate. Knowledge of the degree to which these groups differed would have strengthened this study. Because a large number of VLBW children are born into lower socioeconomic families, the degree to which results of the current study can be generalized to VLBW children in general is questionable. However, approximately one-third of both the VLBW and full-term groups of children were from lower socioeconomic families. Therefore, this group was represented at least to some degree in both samples. Nevertheless, caution should be used when relating results of this study to VLBW children from lower socioeconomic backgrounds. It should also be mentioned that samples in this study lacked children from hispanic backgrounds as well as children from large metropolitan areas. Therefore, caution should be used in generalizing results of this study to children with these demographic characteristics.

A third limitation to this study was related to medical advances that have occurred in the past decade and those that will occur in the future. Rapid advances in medical technology will most likely have a profound impact

on long range effects of very low birthweight. Therefore, the degree to which results of this study will be generalizable to VLBW children born today is questionable.

Finally, the instrumentation used in this study could potentially influence generalizability of results. The significant results obtained in this study were related to the test used in the study. The test of choice, the Cognitive Assessment System, was not fully developed at the time of the study. The final selection of items had not been accomplished, normative data were not yet available, and the reliability of scoring procedures had not been entirely established. The Cognitive Assessment System was chosen over existing instruments because it had been shown to provide a better measure of the dependent variables of interest. However, the efficiency with which the Cognitive Assessment System measures these variables was still being investigated at the time of the study. Sufficient research had been conducted on the Cognitive Assessment System to establish adequate reliability and validity of test items. Therefore, the instrument was considered to be acceptable for the current study.

The provision of a demographically similar control group in this study should have minimized limitations resulting from lack of normative data. However, the control group used in this study was quite small and this

should be considered when attempting to generalize results. Several interrater reliability checks were conducted throughout the study, thereby minimizing any problems that may have existed in the scoring of the instrument. Although it would have been better to use an established instrument, none could be found that would measure the dependent variables of interest as appropriately as the Cognitive Assessment System. However, the fact that the Cognitive Assessment System was still in the developmental stage at the time of this study needs to be considered when generalizing results of this study.

Evaluation of Hypotheses

Results of the multiple analysis of covariance led to rejection of three of the four null-hypotheses proposed in this study. VLBW children were found to have significantly lower scores than full-term children in the areas of simultaneous processing, successive processing, and attention. Group differences were particularly apparent in the area of attention where the obtained F-value was highly significant ($p=.008$). It was interesting to observe the manner in which many of the VLBW children performed the auditory selective attention subtest. While most of the full-term children tapped one hand on the table, many of the VLBW children used both hands, one for when the man said certain words and the other when the woman said

certain words. More of the VLBW children than full-term children had difficulty performing the task. Six of the VLBW children or 29% obtained zero scores compared to five of the full-term children or 17%.

The null-hypothesis that groups would not differ in the area of organization could not be rejected. Mean scores for the two groups of children were similar in this area and the obtained F-value did not approach significance ($p=.78$). However, it should be mentioned that the VLBW group of children had lower mean subtest scores in all four of the organization subtests. Raw scores can be located in Appendix E. The ranges of raw scores for each of the four subtests differed between the two groups of children. The ranges of raw scores for the visual search subtest were 60 to 210 seconds for the control group and 82 to 370 seconds for the experimental group. In the area of planned codes, the ranges of scores were 23 to 59 correct responses for the control group and 4 to 61 correct responses for the VLBW group. The ranges of scores for the planned connections were 122 to 433 seconds for the control group and 154 to 634 seconds for the VLBW group. Finally, on the matching numbers subtest, the control group had a range of 11 to 23 correct while the VLBW gorup had a range of 2 to 22 correct.

Finally, it should be mentioned that many of the VLBW children had a different appearance than the full-term children. The VLBW children tended to be thin and many were quite clumsy. Additionally, many of the VLBW children seemed to have difficulty staying on task.

Conclusions

There is increasing concern that VLBW children may be at risk for later learning difficulties. The results of this study enabled the investigator to support this concern. Several studies have allowed for the conclusion that children born of very low birthweights have attentional difficulties as neonates (Als et al., 1988), infants (Als et al., 1988; Ruff, 1986), and young children (Blennow et al., 1986). According to synactive developmental theory (Als, 1986), those difficulties stem from neurological changes that occur shortly after birth as a result of an organism-environmental mismatch. According to synactive theory, these physiological brain changes could result in long-term attentional difficulties. The results of the current study allow for the conclusion to be drawn that VLBW children, as a group, continue to exhibit attentional difficulties relative to full-term peers at 8 years of age. The fact that VLBW children in this study had attentional scores that were significantly lower than full-term children suggests that these children are at risk

for later attentional difficulties. The difference in attentional scores found between groups in this study lends support to synactive theory.

Similarly, according to synactive theory, the efficiency with which VLBW children process information may be reduced. Such inefficiency is again hypothesized to be due to the physiological brain changes that result shortly after birth from the organism-environmental mismatch. Although information processing difficulties have been identified in VLBW neonates (Als et al., 1988; O'Reilly et al., 1986), the extent to which these difficulties exist in older VLBW children is unknown. The current study allows for the conclusion that VLBW children at 8 years of age are not as efficient at using information coding processes (i.e. successive and simultaneous) as their full-term counterparts. The significant group differences that were found in the successive and simultaneous areas of the CAS lend support to synactive theory. Results of this study allow for the conclusion to be drawn that children born of very low birthweights are not only at risk for information processing difficulties shortly after birth, but also during elementary school years as well.

Finally, much of the focus of synactive theory involves organization. Als and colleagues (1988) found that VLBW babies were more disorganized as a group than

those babies born at term. This disorganization was found to continue into infancy (Als et al., 1988). Als related these findings to synactive theory, stating that physiological changes occurring shortly after birth could lead to long range organizational difficulties. Similarly, Ruff (1986) found that preterm infants were disorganized in their approach to objects and Cohen and colleagues (1988) found that low birthweight children were less able to organize states as neonates and had more learning problems at age 8. The results of the current study did not allow the investigator to support those research findings or synactive developmental theory. The results of the multiple analysis of covariance enabled the determination to be made that scores in the area of organization on the CAS did not differ significantly between the groups of VLBW and full-term children. Therefore, the degree to which organizational difficulties continue to exist in children born of very low birthweights is questionable based on results of this study.

Implications

Advances in medical technology have resulted in increasing numbers of VLBW children surviving and reaching school age. There has been increasing concern that these children may be at risk for later learning difficulties. Short-term follow-up studies have shown that VLBW children

have attentional, organizational, and information processing difficulties as neonates and infants (Als et al., 1988; Ruff, 1986). Although a few long range follow-up studies have shown VLBW children to be at risk for later learning disabilities (Blennow et al., 1986; Cohen et al., 1988; Hunt et al., 1988), studies in which the processing functions of VLBW children have been investigated are particularly lacking.

The present study examined cognitive processing functions of VLBW children at 8 years of age. Results obtained from this study enabled the investigator to conclude that VLBW children as a group continue to be at risk for attentional and information coding difficulties during elementary school years. These findings have several implications for educators and others who work with VLBW babies and children.

First, educators need to be aware of the increased risk status of VLBW children for attentional difficulties during elementary school years. It may be necessary to intervene with these children so as to enhance the attentional abilities that they have. For example, changes in seating arrangements, length of assignments, visual aids and manipulatives, and the number of environmental distractions may be helpful for the VLBW child with attentional difficulties. Similarly, early

interventionists can emphasize attentional activities in their work with young children born of very low birthweights. Perhaps intensive work in this area beginning as early as infancy can prevent or minimize later attentional difficulties, although the investigator found no support for that contention. Relatedly, school psychologists need to be alert to the increased risk status of VLBW children for later attentional problems. In planning assessments for these children, it will be important to include measures sensitive to attentional processes.

A second implication of this study involves the coding processes of VLBW children. VLBW children scored significantly lower than their term-birth counterparts in both coding processes. In other words, weaknesses were apparent in both successive and simultaneous processing. Educators need to be alert to possible information coding weaknesses in these children. Information may need to be presented to the VLBW child in various forms in order to ensure successful processing of it. For example, a new word may be taught using configuration cues, a whole-word approach, phonetic approaches, and pictorial association cues. Because weaknesses may exist in both coding processes, the VLBW child may need to make use of both successive and simultaneous approaches when presented with

new information. Knowledge of such coding weaknesses also has implications for school psychologists who can assist teachers by providing information on a child's coding strengths and weaknesses. It is important that school psychologists incorporate such measures into their evaluations of VLBW children as information coding processes appear to be weak for these children as a group.

The current study did not find VLBW children to differ as a group from those born at term in the area of organization. However, the degree to which organization as measured by the CAS is related to organized behavior in a classroom setting is still not known entirely. It is possible that the CAS does not measure the same organization skills as the K-Box and other measures that have been previously used in research. Because several researchers have previously shown organizational difficulties to exist in VLBW children, it would seem premature to dismiss the need to work with VLBW children in the area of organization on the basis of results of this study. Although organization is considered to be a separate process, it is closely linked with other processes. Consequently, as organizational processes improve, other processing functions may improve also. For example, the child who is organized in approaching a new learning task may also be able to attend better and process

or code new information more efficiently. Therefore, the need to continue assisting VLBW children in developing organizational skills should not be negated by the results of the current study.

Finally, results of this study have implications for those who work in intensive care nurseries with VLBW babies. Several authors have suggested that intervention with VLBW neonates is essential for promoting normal development (Als, 1986; Lawhon & Melzar, 1988). There is much that can be done to minimize the organism-environmental mismatch that exists with preterm birth. The findings of this study allow the investigator to support synactive developmental theory and suggest that faulty adaptation patterns may occur shortly after birth, leading to long range processing difficulties. Although additional research is needed in this area, intervention with VLBW babies shortly after birth would seem warranted.

Recommendations for Future Research

Future research should be focused upon the following areas:

1. Additional long-term follow-up studies. There is a need to continue to examine processing functions of VLBW children at school age. The degree to which attentional and coding difficulties continue to exist at later ages is still unknown. Additionally, there is a need to replicate

the current study with other samples of VLBW children, specifically those of lower socioeconomic backgrounds and those from larger metropolitan areas. It would also be beneficial to examine the processing functions used as dependent variables in this study using the final version of the CAS and the national normative data that will accompany it. Use of other instruments to evaluate these processing functions could also be an area for future research. Larger samples of VLBW children would also be desirable in future studies of cognitive processing functions.

2. Effectiveness of intervention strategies. Future research could focus on the effects of various intervention strategies on the processing functions of VLBW children. These could be either short-term or long range follow-up studies. For example, it might be of interest to examine the effects of teaching organizational skills through such means as metacognitive strategies on other processing functions such as attention. As a long range follow-up study, the effects of teaching organizational skills in an early intervention program could be linked to performance in kindergarten. Relatedly, following the effects of intervening with VLBW babies in the intensive care nursery would be an area for future research.

3. Predictive studies. The relationship between neonatal variables and later processing functions could be the topic of future research. For example, the VLBW neonate's ability to habituate to novel stimuli or regulate states may be related to attentional or organizational processes in later childhood. Determination of predictive variables would be beneficial in targeting children for early intervention.

4. Correlational studies. The extent to which processing functions measured in this study correlate with other factors such as achievement is unknown and could be the focus of future research.

Summary

The current study explored cognitive processing functions of VLBW children at 8 years of age. The four processing functions, organization, simultaneous processing, successive processing, and attention, were measured by the Cognitive Assessment System. The performance of a VLBW sample of children was compared with that of a demographically similar group of full-term children across the four areas of the CAS using multiple analysis of covariance. Although groups were similar in terms of age, race, gender, and socioeconomic status, covariates were used in the analysis to ensure pre-experimental equality of groups on relevant variables.

Results of the data analysis allowed for the conclusion that the VLBW group of children had significantly lower scores in three of the four areas of the CAS. The most significant difference was found in the area of attention, but both coding processes (i.e. simultaneous and successive) differed significantly between the two groups. Scores in the area of organization were not found to differ between the two groups of children.

The results obtained in this study enabled the investigator to support previous research findings and synactive developmental theory. Based on results of this study, it appears that VLBW children continue to have information processing and attentional difficulties at 8 years of age. With increasing numbers of these children surviving and reaching school age, these results have several implications for educators.

There is a need for additional longitudinal research to examine the processing functions of VLBW children. Future research could include larger sample sizes, different populations, and different instrumentation. Additionally, there is a need to examine the extent to which processing functions correlate with other factors such as achievement and the degree to which intervention can improve processing functions. Finally, future research could involve predictive studies whereby neonatal or infant

variables can be identified that predict later processing functions.

APPENDIX A

INTRODUCTORY LETTER

Dear (Parent's Name):

Your child, (Child's Name), has been selected to be in a study at Sacred Heart Hospital to follow premature babies. We invite your child to be a participant in this study. The study will be conducted by a licensed school psychologist who is a doctoral student at the University of Florida. We are seeking children who were born prematurely and others of the same age who were born after term pregnancy. The study will require about two hours of your child's time to complete some paper and pencil tests. The tests which are designed to be fun for children focus on planning and attention skills as well as the ways that children think and solve problems. If your child participates in the study, all results will be confidential and you can withdraw from the study at any time. The test that will be used in this study is new and still being developed, so we will not be able to tell you how your child did compared to other children. However, an examiner will be happy to talk with you about your child's test behavior (such as cooperation and attention span). Nothing will be done that could harm your child.

Please complete the following forms and return them in the envelope provided. If you give permission for your child to participate in this study, a letter will be sent to you within the next few weeks. At that time, you will be given a tentative appointment time.

Please return these forms within the next few days. Feel free to contact me if you have any questions at 474-7469 during the day or at 477-3361 in the evenings. Thank you for your cooperation.

Sincerely,

Debra Davidson
School Psychologist
Developmental Intervention
and Follow-up Program
Sacred Heart Hospital

APPENDIX B

DEMOGRAPHIC INFORMATION FORM

In order to select children to participate in this study, we need to know some information. All information that you provide on this form will be confidential. If you give permission for your child to participate in this study, please complete the following information and return this form in the envelope provided along with the permission form on the next page.

Child's Name: ______________________________

Child's Date of Birth: ____________________

Child's Age: ____

Child's Sex: ____

Child's School: ___________________

What is your child's race? (Check one)

___Black ____White ____Other

Mother's Education at Time of Child's Birth: (Please check one)

Years Completed in School

____Less than 12th Grade

____High School Diploma or Equivalent

____1-3 Years of College or Technical School

____4 or more years of College

Mother's age at the Time of Birth: __________

APPENDIX C

PERMISSION FORM

Please read this form and indicate whether or not you give permission for your child to participate in this study. Return one copy of this form with the information form in the envelope provided. Keep the other copy of this form for your records.

I understand that participation in this study is voluntary and that I can withdraw from the study at any time without prejudice.

I understand that results will be confidential and that my child's name will in no way be used when results of this study are reported.

I understand that my child's scores will be included with the scores of the whole group being studied and that they will not be reported separately.

I understand that my child will not receive any immediate benefit for participating in this study.

I have read and I understand the procedure described on the attached letter. I agree to allow my child to participate in the study and I have received a copy of this form.

PLEASE CHECK ONE

_____I give permission for my child,__________________________ , (Please write child's first and last name), to participate in this study.

_____I do not want my child, ________________, to participate.

____
(Parent's or guardian's signature	__________ DATE

____
(Parent's or guardian's signature)	__________ DATE

____
(Investigator's Signature)	__________ DATE

If you have any comments, please list them below. Comments:

APPENDIX D

APPOINTMENT LETTER

Dear (Parent's Name):

Thank you for your participation in our study! Your cooperation is greatly appreciated and we look forward to meeting with your child.

An appointment time has been arranged for you. If this time is not convenient, we will arrange an alternate time for you. Testing will be conducted at the Developmental Follow-Up Center. A map is enclosed for your convenience. We request that you bring your child to the center at the time listed below. If you have any additional questions about the study or the tests that will be admistered, an examiner will be happy to talk with you at that time. We recommend that you drop your child off and return later since the testing will require approximately two hours to complete. Your child will be supervised at all times while at our center in the event that the examination takes less time than expected.

Because this test is new, we will not be able to give you information about how your child did compared to other children. However, we will be happy to talk with you about how your child did as far as cooperation, attitude, and attention span.

Again, we thank you for your cooperation.

Your appointment is scheduled for __________, on ________________.

PLEASE CHECK ONE:

_______Yes, I want my child to participate and will be there at this time.

_______Yes, I want my child to participate , but transportation is a problem. Please contact me at ______________(Phone Number) to make other arrangements.

_______Yes, I want my child to participate, but I can't make it at this time. Please call me at ________________(Phone Number) to set up another time.

_______No, I've decided that I don't want my child to participate.

_______Other. If none of the above is your choice, please make comments below.

APPENDIX E

CAS RAW SCORES

Raw Data for the Control Group

Subtests

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1)	131	35	391	17	5	17	7	10	13	12	7	7	99	37	0	32
2)	79	52	122	16	7	15	5	10	6	13	11	4	69	65	0	59
3)	87	46	259	17	7	18	5	6	17	19	6	7	71	59	31	64
4)	107	24	185	18	14	18	11	14	14	17	12	4	93	58	10	51
5)	113	50	255	20	10	18	13	14	15	23	7	3	69	55	41	54
6)	79	45	171	18	10	18	9	12	9	14	10	6	78	61	33	61
7)	88	53	324	20	9	23	11	11	15	22	12	7	75	67	30	56
8)	106	45	237	15	7	16	8	19	14	18	9	4	123	64	0	53
9)	113	23	264	16	5	16	8	7	10	10	7	5	110	56	31	56
10)	157	30	391	16	5	17	7	7	9	17	7	5	121	61	27	27
11)	148	35	433	11	6	14	8	8	10	18	7	4	108	51	38	48
12)	164	39	326	18	7	12	9	13	12	14	9	5	99	47	0	39
13)	122	39	303	13	4	21	8	7	10	19	3	4	62	49	12	57
14)	154	41	279	18	7	15	8	7	8	10	11	6	68	72	25	22
15)	89	47	204	19	7	18	11	10	11	21	9	4	51	65	27	58
16)	210	41	368	13	5	15	9	8	7	8	9	6	82	59	27	45
17)	139	32	342	14	5	11	8	3	4	5	5	4	68	48	0	43
18)	125	55	151	18	8	13	9	11	8	16	13	5	59	70	8	47
19)	99	39	191	17	7	18	12	14	8	19	11	7	64	67	32	52
20)	258	34	285	14	8	17	11	6	10	18	8	5	131	39	16	32
21)	101	33	303	13	6	15	8	7	12	14	8	5	146	55	15	51
22)	105	41	220	16	5	18	8	6	8	14	10	5	122	66	30	54
23)	60	53	198	21	7	20	11	8	16	18	13	4	74	60	33	52
24)	87	50	198	16	7	17	8	6	9	15	8	5	65	70	37	53
25)	99	57	266	23	7	16	7	10	12	15	8	6	78	75	48	50
26)	109	59	194	22	9	19	8	16	12	19	10	7	71	78	15	63
27)	100	39	254	21	6	17	9	21	9	18	13	4	47	79	20	58
28)	119	48	323	11	7	15	10	9	10	17	9	7	94	59	59	51
29)	179	40	358	14	5	12	6	3	7	12	6	3	92	57	27	52
30)	108	52	145	21	7	16	8	17	13	23	15	6	70	83	41	61

Subtest Key

1. Visual Search (Seconds)
2. Planned Codes (Number Correct)
3. Planned Connections (Seconds)
4. Matching Numbers (Number Correct)

5. Design Construction (Number Correct)
6. Simultaneous Verbal (Number Correct)
7. Figure Memory (Number Correct)
8. Matrices (Number Correct)
9. Word Order (Number Correct)
10. Sentence Repetition (Number Correct)
11. Color Ordering (Number Correct)
12. Hand Movement (Number Correct)
13. Expressive Attention (Seconds)
14. Receptive Attention (Number Correct)
15. Auditory Selective Attention (Number Correct)
16. Number Finding (Number Correct)

Raw Data for the Experimental Group

Subtests

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1)	185	32	236	19	7	14	7	7	7	11	8	54	96	50	0	40
2)	130	29	275	14	4	16	10	6	9	11	10	6	62	49	7	44
3)	108	50	298	17	8	19	9	9	13	16	9	5	85	63	16	55
4)	133	44	269	11	7	17	9	13	9	17	10	4	78	63	7	53
5)	120	34	440	12	3	13	7	4	6	11	4	4	75	69	0	40
6)	192	25	389	14	5	18	9	8	12	15	10	5	125	42	0	32
7)	110	33	358	17	5	13	9	7	17	18	8	4	131	58	21	42
8)	137	30	580	13	3	17	4	4	8	8	6	4	181	36	13	26
9)	122	50	154	18	6	16	8	10	8	9	10	6	62	61	0	39
10)	370	4	634	2	3	10	5	2	6	7	5	5	64	36	0	12
11)	161	50	231	21	8	19	10	18	10	13	14	6	133	69	9	60
12)	137	34	374	15	6	19	9	9	13	21	9	3	106	49	19	41
13)	145	35	519	18	5	13	7	8	8	10	1	5	76	62	0	32
14)	114	44	373	18	7	20	10	19	10	19	10	3	75	54	27	60
15)	143	47	406	19	7	17	8	18	10	10	10	4	92	59	25	55
16)	102	41	164	17	6	18	8	14	11	12	7	5	65	68	23	56
17)	82	61	165	22	7	20	9	6	19	26	9	6	59	66	30	60
18)	116	40	176	14	7	18	9	18	14	16	12	3	49	65	27	59
19)	239	7	553	10	6	14	4	0	11	11	6	4	113	23	3	29
20)	158	29	315	18	6	18	8	10	7	11	8	4	135	56	3	43
21)	163	27	370	15	7	14	8	9	7	14	8	4	120	43	2	50

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Debra B. Davidson was born Debra Bruininks in Grand Rapids, Michigan. She was raised in Miami, Florida, where she attended Southwest Miami High School and graduated in 1975. She received a Bachelor of Arts degree from Hope College in 1979 where she majored in psychology and elementary education. In 1980, Debra received a Master of Arts degree from the University of West Florida where she majored in school psychology.

After receiving a Master of Arts degree, Debra worked as a school psychologist in Leesburg, Florida. She married Jim Davidson in March of 1984. In 1986, Debra and Jim moved to Gainesville, Florida, where she received a Specialist of Education degree in 1987 and began doctoral course work at the University of Florida.

Debra performed her doctoral internship during the 1988-1989 school year at the Developmental Intervention and Follow-up Program through Sacred Heart Hospital in Pensacola, Florida. She currently works as a school psychologist in Vero Beach, Florida, where she and her husband reside. Their first child, Christopher John, was born on April 29, 1990.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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